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Offshore Platform Evaluation System (OPES)

Phase 1 Final Report

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Executive Summary

BACKGROUND

Assuring the safe continued operation of older existing platforms is a growing issue. The Minerals Management Service (MMS) is facing the problem of having to review the performance of over 3,800 platforms located in US OCS waters. Industry operators are facing growing economic pressure to continue operations on many of these platforms to maintain oil and gas production.

Proper evaluation of the continued reliable use of these platforms involves several technologies. Inspections are required to determine the existing condition of the platform. Strength/reliability assessments are required to, 1) determine if the platform has sufficient structural integrity and, 2) evaluate the cost effectiveness of various remedial programs if inadequate performance is indicated. Maintaining this information in a database along with maintenance information and possible remedial work is important for the MMS and operators alike.

SCOPE OF WORK

The MMS has initiated the development of a computer based system that integrates these technologies. The intent is to provide a system that assists in evaluation of the structural integrity of existing offshore platforms.

Specific objectives are:

- Provide a system for archiving data on a single platform or fleet of platforms
- Provide an interface between inspection results and structural assessments
- Provide a process for rapid first-order estimates of platform structural integrity

- Provide a system for on-going evaluation of platform performance that can be used to help determine when, where and how much to inspect, evaluate and maintain platforms.
- Simplify the process for submitting inspection and assessment data to the MMS
- Use existing computer codes as much as possible such as the CAIRS inspection program and the CAP structural analysis program, but still be able to interface with other programs.

This type of integrated technology is not currently available in the industry and will provide a valuable tool that will lead to more focused, organized and cost effective platform assessments. Note that the system is not intended to make decisions or set criteria for performing inspections, evaluations or maintenance; rather, it will provide the necessary data that can be used by regulators or operators in combination with in-house procedures and policies for making these types of decisions.

DEVELOPMENT APPROACH

This report describes Phase I of the project which focuses on developing the overall technical approach and provides an initial outline of the system. Phase I is funded by the MMS. Phase II will develop the detailed approach and a detailed computer specification. Phase III will implement the approach into a computer code. Phases II and III are being planned based upon combined MMS and industry participation.

SYSTEM DESCRIPTION

The system has been tentatively called OPES for Offshore Platform Evaluation System. Figure ES-1 shows the general architecture of the system which is actually a series of existing and soon to be developed computer programs which interact via a central database. The basic capabilities of the system as they are currently defined are as follows:

- **Data Storage and Exchange.** The core of the system is a central database which archives and manages data relevant for evaluating platform structural integrity. Data can be stored for a single platform or a fleet of platforms. The central database serves as the communication link between external programs. Once a program is compatible with the central database, it is compatible with other programs linked to the system.

- **Data Input and Updating.** Data can be input or updated in the central database via interface with existing computer codes. Regulator or operator databases can be used to input the initial platform information (location, date of installation, geometry, etc.) while inspection programs can be used to update the information to reflect the platform's current condition.

- **Data Processing.** The Central Database information can exchanged with external programs for processing. Examples are a simplified structural assessment using a screening program, a detail structural assessment using a nonlinear computer code, or a reliability evaluation. The screening program will be developed as part of the OPES project and will rapidly assess the structural integrity of a platform or fleet of platforms to assist in determining the specific platforms and specific location on the platforms that require attention.

The individual sections of this report further describe each of these activities, including: a preliminary listing of the central database contents; operation and capabilities of the central database; interface with computer codes such as CAP and CAIRS; proposed approaches for the screening program; potential future interfaces such as a reliability program; and software/hardware issues. Note that the intent of the Phase I study is to investigate each of these technical areas and outline how they can be brought together to operate in a single integrated system. Detailed development will occur in later phases of the project.

SOFTWARE AND HARDWARE

OPES will likely operate on IBM-compatible 386-986 based PC's. The program will interface with desktop workstations (SUN). The program will be easy to use and operate with a modern graphical user interface. Appendix C provides a preliminary computer specification for OPES. In addition, a demo version which illustrates the proposed user interface of the program has been developed.

RECOMMENDATIONS

This project has developed an outline for an integrated system for evaluating existing offshore platforms. The system will provide a complete evaluation process which does not currently exist within the industry. This program will be a significant time and expense saver when performing platform evaluations. It is recommended that the next phases of the project, which are being planned using joint industry participation, be pursued using the approaches developed in Phase 1 and described in this document.

Other, specific recommendations of the project include:

- Use a central database as a "warehouse" for storing data and exchanging data between programs. Once an external program is compatible with the central database it is compatible with other external programs linked to the system.

- Develop a "screening" program which provides rapid strength evaluations for platforms based upon qualitative assessment of known platform conditions (e.g. deck elevation) and/or quantitative assessment using force-capacity algorithms or simplified structural analysis.

- Provide compatibility with other programs beyond CAP and CAIRS. CAP and CAIRS will be 100 percent directly compatible with OPES. Other programs will be compatible via a "generic" interface for exchanging data with the central database. This allows use of OPES by operators who do not use these programs.

- Ensure OPES is useful without assistance from any external programs. In some cases, an operator may not have access or interest in specialized external programs (e.g. CAP or CAIRS). OPES will still provide a powerful tool via the central database for archiving and querying data, and the screening program for performing first order strength assessments.

Section 1
Introduction

1.1 BACKGROUND

One of the major concerns of today's offshore industry is the assessment and maintenance of existing offshore platforms. There are approximately 3,800 offshore structures located in US Outer Continental Shelf (OCS) waters (Table 1-1), with about one third at or beyond their originally intended service life of 20 to 25 years (MMS, 1992). These older platforms often suffer from a variety of problems including inadequate original design criteria, strength degradation caused by corrosion and fatigue, and damage due to exogenous causes such as dropped objects and impacts from supply vessels. Many of these platforms would be considered deficient if evaluated according to today's more stringent design standards, yet most of these platforms have operated in a safe and efficient manner and if adequately maintained, will continue to operate safely into the foreseeable future.

Given the current situation of depressed oil and gas prices combined with the high costs and political uncertainties of replacing these aging structures with new platforms, operators face the challenge of using existing platforms to the fullest extent possible. Likewise, it is in the best interest of government regulators such as the MMS to encourage continued safe use of these platforms in the interest of keeping domestic production at an acceptable level. Therefore, a mutual strategy needs to be developed that serves the best interest of operators and regulators alike – the development of assessment procedures and tools that help ensure safe, yet economically justifiable operation of existing platforms.

Over the past six years, several industry and academic studies have devoted significant effort toward this issue, such as industry symposiums and workshops (MMS, 1991), the AIM joint industry projects (PMB, 1987-1990), academic studies (Aggarwal, 1991), and the development of several computer programs such as the CAP (PMB Engineering Inc.) and CAIRS (Solus Schall) programs. In several cases, the MMS and industry have jointly participated in development of the technology. This has led to development of technologies that are for the most part mutually acceptable to government and industry alike

1.2 OVERVIEW OF PROJECT

Based upon this background and the continuing need to develop and apply evaluation technology to existing platforms, the MMS has funded initial development of a computer aided system that combines the abilities of several of existing technologies. The intent is to develop a system that can be used to archive data related to existing offshore platforms, update this data according to recent inspections, and then using this data, assess the structural integrity of the platform. The system is structured as a tool to assist in these evaluations and is not intended to make decisions or establish criteria.

Figure 1-1 shows the general configuration of the proposed system. The system is called Offshore Platform Evaluation System or OPES. The system is actually a network of new and existing programs that interact by exchanging and processing data. The goal is to provide a computer based system that can be used to evaluate the structural integrity of existing offshore platforms. OPES will likely operate on a PC and/or workstation.

There are three main activities performed by the system, with each defined as follows:

1. **Data Storage and Exchange**

   The core of the system is a central database containing detailed information related to a platform or "fleet" of platforms. The database is structured to store information that is relevant for assessing the structural integrity of offshore platforms, such as platform configuration, site conditions, inspection results, strength evaluation results, etc. The database information will be transferable between programs compatible with the system. The central database will be the "compatibility link" between a number of external programs that can be used in the evaluation process. For example, new inspection data detailing member damage can be input to the central database from CAIRS and then transferred to CAP to update a structural model of the platform to account for the damage. The process will be automated as much as possible with the central database converting CAIRS damage location information into a specific format suitable for transfer to CAP and inclusion into the structural model. Note that OPES will be structured so that CAP and CAIRS are 100 percent compatible with the central database, due to the use of these programs by the MMS and other operators. However, other structural analysis or inspection programs will also be able to interact with the database via a generic interface.

2. Data Input and Updating

The information required for the database can be initially input or updated using existing regulator and operator databases. This allows full use of existing databases or special programs currently used by regulators and operators. For example, the MMS currently maintains a database of all platforms in OCS waters. The database contains key information such as platform name, location, water depth, type of facility, etc. Table 1-2 shows some of the information available from the MMS database. Operators may also have their own in-house databases to initially supply the central database with the necessary information. In order to expedite this process, OPES will be designed to link with existing databases via a generic interface. A key feature of OPES is the interface with CAIRS or other inspection programs for updating the central database information based upon the latest inspection results.

3. Data Processing

The information from the central database can be transmitted to other external programs for processing. These programs can in turn transmit the processing results back to the central database for storage and/or use by other programs. Platform strength analysis is an essential part of structural integrity assessments. Two interfaces are planned for this activity. The first interface is with a "screening program" that uses simplified techniques to determine first order strength estimates for a platform. The screening program will be developed as a portion of this project. The second interface is with a structural analysis program such as CAP. This interface provides for an in-depth strength analysis. As previously noted, structural analysis programs other than CAP can interact with the central database via the generic interface. Examples of other potential "future" interfaces with processing programs includes reliability programs (e.g. RELACS (Risk Engineering, Inc.) and PROBAN (Veritas Sesam Systems, Inc.)), inspection planning programs and perhaps a topsides database.

OPES has been planned to provide complete platform assessment capabilities using a combination of new and existing programs. OPES will be useful for regulators and operators alike. The MMS will use the system to archive and evaluate platform information submitted by operators.

Most operators have a significant number of platforms in OCS waters as shown by Table 1-1. OPES will be helpful to these operators in assessing their own specific fleet of platforms. A key aspect of the program for operators is that all information can be contained in a single location and that all information and evaluations will be consistent. As an added benefit, any work performed by an operator would by default be compatible with the MMS in-house system. This would significantly decrease operator time and costs associated with submitting required inspection and assessment data in a format that is consistent with and acceptable to the MMS.

An operator can also use the system to assist in planning inspections, structural assessments, and remedial work. The screening program can be used to identify and prioritize platforms requiring inspection. The screening program can also be used to identify critical members and zones in a platform where inspections/repairs can be focused. The result will be a more logical and efficient approach to maintaining large numbers of platforms.

1.3 MULTI-PHASE JOINT INDUSTRY APPROACH

The development of this type of system is a multi-disciplinary effort and is best developed using a Joint Industry Project (JIP) where input and direction is available from several sources. In addition, this type of effort is best developed using a joint regulator-industry approach ensuring that the needs and concerns of each are addressed. Therefore, a multi-phase JIP development effort using regulator and industry input is planned as shown in Figure 1-2.

Phase I involves the further identification and understanding of what is required for such a system and how the system will be developed into a computer code. Phase I is also intended to develop sufficient documentation to generate industry interest in further developing the system. Phase I is funded entirely by the MMS and is reported in this document which focuses on the technical content and processes planned for the system. A preliminary specification which describes the software and hardware portion of the system is included as an appendix. Finally, a "demo" computer code has been developed which illustrates operation of the user interface for the program.

Phase II further develops the technical content and processes of the system (based upon JIP input) and further develops the specification to the detail required for computer coding. A prototype of the final program will be developed. This is planned as a JIP with participation by between 5-10 regulator and industry sponsors. Total cost would be approximately $75,000 with a 6 month schedule.

Phase III develops the final system and documentation. This is also planned as a JIP with similar participation. Total cost would be approximately $200,000 with a 1 year schedule.

1.4 OUTLINE OF DOCUMENT

This section has provided a general overview of the project including a brief description of OPES. The remainder of the report describes OPES in more detail with a summary of each section provided below.

Section 2 provides an overview of the system including definition of operational requirements and identification of the individual system components and their associated capabilities.

Section 3 describes the central database functions and capabilities. Each of the key data files, such as structural data and site data, are described including a preliminary listing of data for each. Several of the databases are further described in some of the relevant subsequent sections. The development of the central database is a major portion of the OPES project.

Sections 4 through 6 describe the OPES interface with existing programs such as operator databases, inspection programs, and structural analysis programs. The transmission and exchange of data with the central database is described. The capabilities of the programs are also discussed. The development of interfaces for these types of programs is a portion of the OPES project.

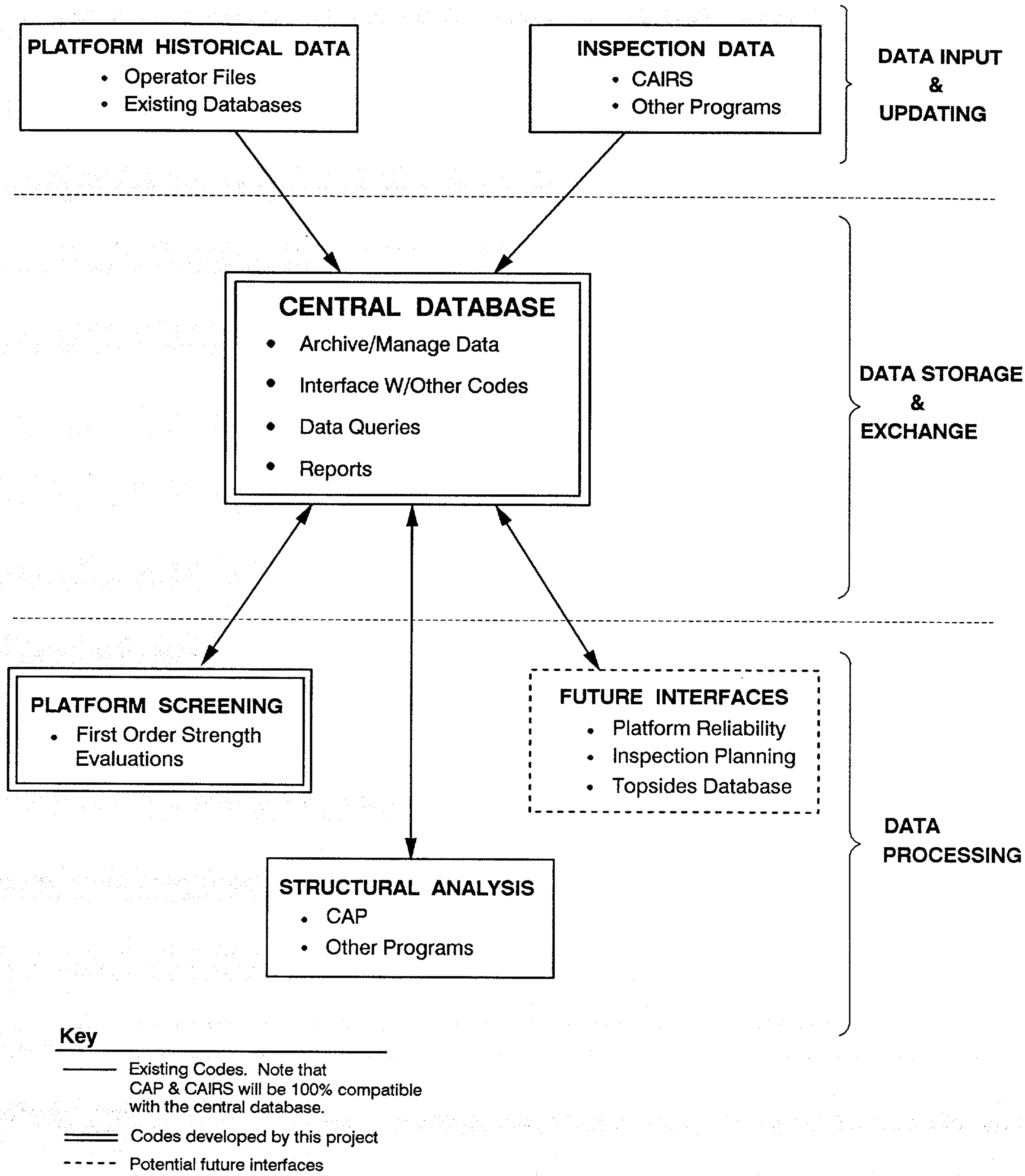
Section 7 describes several proposed screening processes that can be included within OPES. Further development and eventual coding of the screening procedures are a portion of the OPES project.

Section 8 describes interfaces with reliability codes, inspection planning programs, etc., that can potentially be included in future OPES work. A key factor here is that OPES will be structured so that it will be able to interface with these programs with minimal revisions to OPES or the programs. Depending upon participant interest, development of several of these types of procedures and programs may also become a portion of the OPES project.

Section 9 describes implementation of OPES into a computer program including general architecture and format of the program. Hardware and software related issues are also described.

Section 10 provides general conclusions and recommendations resulting from the Phase I effort.

Several appendices are included. Appendix A provides a complete listing of the preliminary central database. Appendix B provides further descriptions of the CAP and CAIRS computer programs which will be compatible with OPES. Appendix C provides a preliminary computer specification for OPES and extends the discussion of Section 9. Appendix D (actually a PC floppy disk) is a demo program illustrating the proposed operation of the OPES user interface.

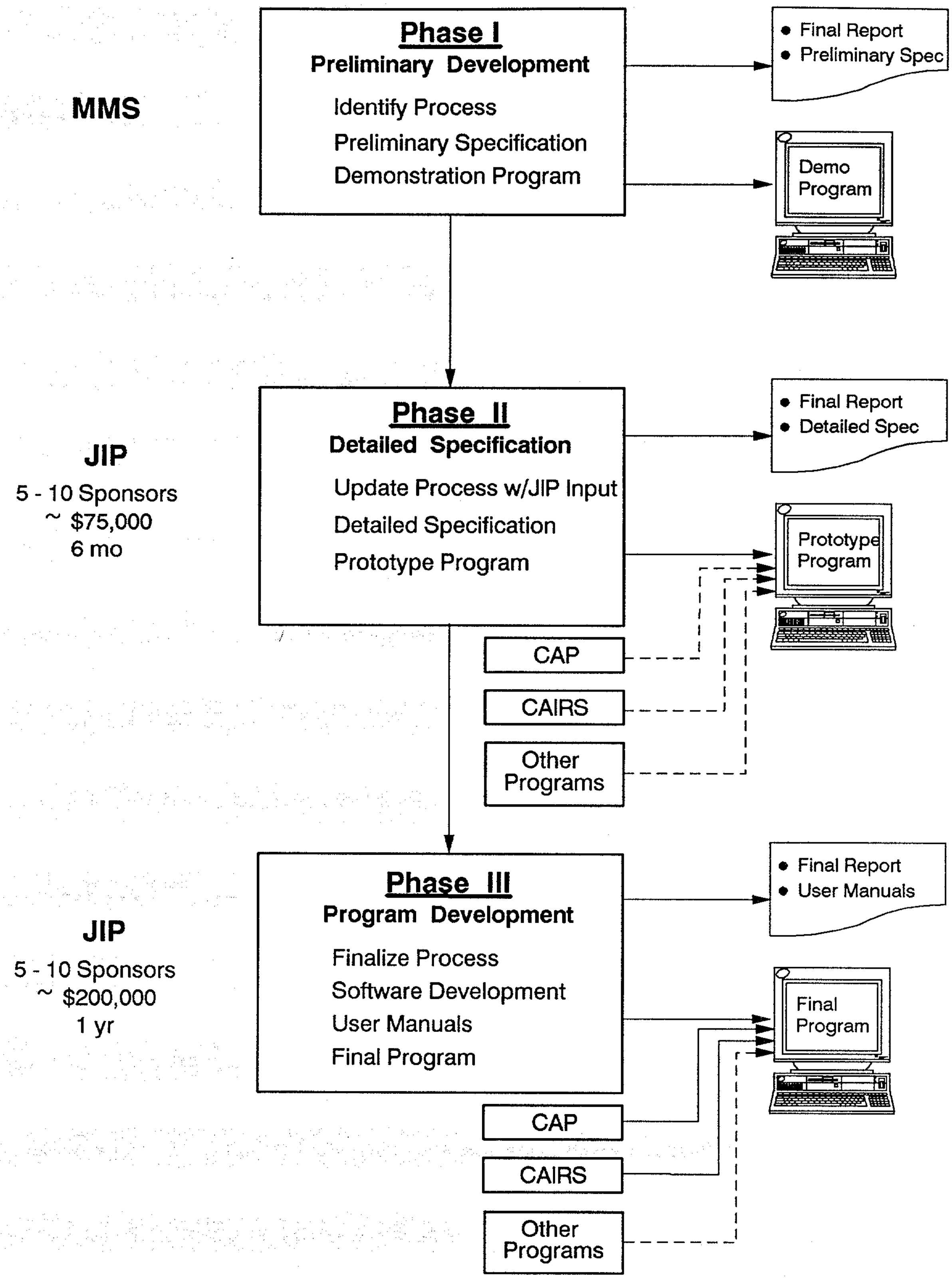


OPES

Offshore Platform Evaluation System

Figure 1-1

.031\OPES\FIG-1-1



OPES DEVELOPMENT

MULTI-PHASE APPROACH

Figure 1-2

.031\OPES\FIG-1-2

Table 1-1 US OCS PLATFORM OPERATORS - SORTED BY NUMBER OF PLATFORMS (MMS, 1992)

Operator	Number of Platforms
Chevron USA Inc	803
Odeco Oil & Gas Co	299
Mobil Oil Exploration and Production	233
Shell Offshore Inc	222
Unocal Exploration Corp	221
Texaco Inc	193
Conoco Inc	155
Kerr-McGee Corp	120
Exxon Corp	96
Hall-Houston Oil Co	77
Amoco Production Comp	74
Altlantic Richfield COmp	59
Phillips Petroleum co	55
Mobil Exploration and Production	55
Amerada Hess Corp	53
Samedan Oil Corp	51
Marathon Oil Co	49
Pennzoil Explor and Prod	38
Corpus Christi Oil and Gas Co	36
Allliance Operating Corp	36
W & T Offshore Inc	35
CNG Prod Comp	34
Elf Aquitane Oper Inc	33
Seagull Energy E&P Inc	32
Walter Oil & gas Corp	28
Oxy USA Inc	27
Sonat Explor Co	26
Nerco Oil and Gas Inc	25
Mobil Producing Texas & New Me	25
Oryx Energy Co	24
Union Pacific Resources Co	23
Diamond Shamrock Offshore Part	22
Union Exploration Partners LTD	20
Torch Oper Co	20
Howell Petroleum Corp	20
Hunt Oil Co	19
Taylor Energy Co	18
Forest Oil Co	18
Teaxaco and Explor Prod	17
Placid Oli Co	17
Century Offshore Management	17
Freeport-McMoran Oil & Gas	16
Union Texas Petroleum Corp	15
Sante Fe International Corp	15
Four Star Oil & Gas Co	15

Table 1-1 US OCS PLATFORM OPERATORS - SORTED BY NUMBER OF PLATFORMS (MMS, 1992) (Continued)

McMoran Oil & Gas Co	14
Freeport-McMoran Resource Part	14
Mesa Operating Limited Part	12
Koch Explor Co	12
General Atlantic Resource Inc	12
Enron Oil & Gas Co	12
Energy Dev Corp	12
Elf Explor Inc	12
Total Minatome Corp	11
Shell Oil Co	11
PSI Inc	11
Pennzoil Co	11
Ivory Prod Co	11
Brooklyn Union Exploration Co	11
BP Exploration Inc	11
Union Oil Co of Ca	10
Newfield Exploration Co	9
Anadarko Petroleum Comp	9
Houston Oil & Minerals Corp	8
Gas Trans Corp	8
Apache Corp	7
Sandefer Offshore Operating	6
Cockrell Oil Corp	6
Transco E & P	5
Mobil Oil Corp	5
Hughes Eastern Petroleum Inc	5
Great Western	5
Canadianoxy Offshore Prod	5
Zilkha Energy Co	4
Wayman W Buchanan Inc	4
Stone Pet Co	4
Norcen Explorer Inc	4
Mitchell Energy Co	4
Mesa Petroleum Co	4
Flash Gas & Oil Southwest	4
Adobe Resources Corp	4
Zapata Explor Co	3
Wacker Oil Inc	3
Roberts & Bunch Offshore Inc	3
Freeport-McMoran Inc	3
Columbia Gas Dev Corp	3
Ashland Exploration Inc	3
TXP Operating Co	2
Shell California Prod Inc	2
Seko Energy Inc	2
PSI Energy Resources Inc	2
Partners Oil Co	2
Pacific Operators Inc	2
Matagorda Island Dev	2

Table 1-1 US OCS PLATFORM OPERATORS - SORTED BY NUMBER OF PLATFORMS (MMS, 1992) (Continued)

Marathon Petroleum Co	2
Louisiana Land and Explor	2
Global Marine Oil & Gas	2
FMP Operting Co A Limit	2
ANR Prod Comp	2
American Exploration Company	2
Agip Petroleum Co Inc	2
Aran Energy Corp	2
Van Pet Inc	1
UMC Petroleum Corp	1
Tenneco Oil Co	1
Tatham Offshore Inc	1
Southland Royalty Co	1
Shell Western E&P Inc	1
Santa Fe Energy Operating Ptrs	1
Quintana Pteroleum Corp	1
Petrobras Americ Inc	1
Pelto Co	1
Kirby Explor Co	1
Harbert Energy Corp	1
Falcon Offshore Operating Corp	1
CSX Oll & Gas Co	1
Conn Enegy Inc	1
Coastal Oil & Gas Corp	1
Cashco Energy Corp	1
Chandeleur	1
BHP Petroleum Americas Inc	1
B T Operting Co	1
Aviva America Inc	1
AEDC USA Inc	1
Totals 123 Operators	3853 Platforms

Table 1-2 EXAMPLE OUTPUT FROM MMS DATABASE

PLATFORM LOCATIONS VS CURRENT DESIGNATED OPERATOR

Page No. 1
03/16/92

COMPLEX ID NO.	STRUCTURE NUMBER	STRUCTURE NAME	AREA BLOCK	LEASE	ABBREVIATED OPERATOR NAME	DISTANCE IN FT FROM LEASE LINES	X COORDINATE	Y COORDINATE	YEAR INSTALLED	WATER DEPTH	DISTANCE IN MILES FROM SHORE
CURRENT DESIGNATED OPREATOR ADOBE RESOURCES CORPORATION											
10492	01	#1 CAISSON	BA 0517	G11279	ADOBE RESOURCES CORPORATION	01550N05750W	002958825.810000	000212290.000000	90	0065	015
10344	01	A	MI 0487	G07194	ADOBE RESOURCES CORPORATION	04336S02126E	002950949.810000	000218176.000000	89	0064	023
23929	01	A	SS 0299	G07759	ADOBE RESOURCES CORPORATION	04504N03580E	000000000.000000	000000000.000000	90	0258	056
23752	01	A	WC 0285	G10566	ADOBE RESOURCES CORPORATION	05337S02006W	000000000.000000	000000000.000000	91	0109	059
NUMBER OF PLATFORMS OPERATED BY ADOBE RESOURCES CORPORATION					4						
CURRENT DESIGNATED OPREATOR AEDC USA INC											
23859	01	A	MC 0486	G06957	AEDC USA INC	06111N04620E	000000000.000000	000000000.000000	90	0582	042
NUMBER OF PLATFORMS OPERATED BY AEDC USA INC					1						
CURRENT DESIGNATED OPREATOR AGIP PETROLEUM CO INC											
20105	01	C	WD 0089	G01088	AGIP PETROLEUM CO INC	04200N06400W	002549177.930000	000098792.100000	69	0220	023
23813	01	A	WD 0089	G01088	AGIP PETROLEUM CO INC	07225S03150E	002550077.930000	000089375.000000	89	0220	023
NUMBER OF PLATFORMS OPERATED BY AGIP PETROLEUM CO INC					2						
CURRENT DESIGNATED OPREATOR ALLIANCE OPERATING CORPORATION											
20683	01	A	EC 0273	G02048	ALLIANCE OPERATING CORPORATION	00716N01994E	001573933.310000	-00083457.440000	72	0180	079
20683	02	A-AUXI	EC 0273	G02048	ALLIANCE OPERATING CORPORATION	00816N01994E	001573933.310000	-00083557.440000	72	0180	079
21345	01	13	EI 0089	00044	ALLIANCE OPERATING CORPORATION	10450S06100W	001870900.560000	000164353.940000	67	0030	020
21346	01	11	EI 0089	00044	ALLIANCE OPERATING CORPORATION	12000S06850E	001872972.720000	000165903.940000	67	0030	020
21523	01	2 & 3	EI 0089	00044	ALLIANCE OPERATING CORPORATION	06500S00675W	001865475.560000	000160403.940000	60	0022	020
22775	01	19	EI 0089	00044	ALLIANCE OPERATING CORPORATION	06012S00315W	001865115.560000	000159915.940000	83	0030	020
22889	01	21	EI 0089	00044	ALLIANCE OPERATING CORPORATION	03858S00728E	001879094.720000	000157761.940000	84	0030	025
21339	01	CF	EI 0090	00229	ALLIANCE OPERATING CORPORATION	01300S01600E	001863200.560000	000155203.940000	60	0023	023
21339	02	CF-HEAD	EI 0090	00229	ALLIANCE OPERATING CORPORATION	01330S01700E	001863100.560000	000155233.940000	60	0023	023
21349	01	9	EI 0090	00229	ALLIANCE OPERATING CORPORATION	00123S01215E	001863585.560000	000154026.940000	70	0022	023
21349	02	0228-10	EI 0090	00229	ALLIANCE OPERATING CORPORATION	00123S01215E	001863585.560000	000154026.940000	82	0022	023
21824	01	10	EI 0090	00229	ALLIANCE OPERATING CORPORATION	01890S00065E	001864735.560000	000155793.940000	72	0019	023
22860	01	11	EI 0090	00229	ALLIANCE OPERATING CORPORATION	03037S00360E	001864440.560000	000156940.940000	83	0022	023
21351	01	2	EI 0093	00228	ALLIANCE OPERATING CORPORATION	02890N00590E	001864210.560000	000151013.940000	59	0022	026
21352	01	8	EI 0093	00228	ALLIANCE OPERATING CORPORATION	01450N01000E	001863800.560000	000152453.940000	68	0020	026
21531	01	6	EI 0093	00228	ALLIANCE OPERATING CORPORATION	00660N01387E	001863413.560000	000153243.940000	59	0022	026
22639	01	9	EI 0093	00228	ALLIANCE OPERATING CORPORATION	01505N00609E	001864191.560000	000152398.940000	82	0023	027
22811	01	11	EI 0093	00228	ALLIANCE OPERATING CORPORATION	04956N00507E	001864293.560000	000148947.940000	83	0025	027
22861	01	12	EI 0093	00228	ALLIANCE OPERATING CORPORATION	06207N00226E	001864574.560000	000147696.940000	84	0025	022

Section 2
Overview of System

2.1 TECHNICAL CAPABILITIES

The purpose of OPES is to simplify the process of tracking and evaluating the structural integrity of existing offshore platforms. In order to provide this ability a set of capabilities were identified which define specific technical operations that are to be performed by the program. These capabilities are defined as follows:

1. **Provide a database for archiving and querying information related to a single platform.** This includes data such as owner, date installed, water depth, last inspection date, known damage (if any), platform capacity (RSR), etc. Data can be defined at a summary level (e.g. damaged braces) or detailed level (e.g. A1-A2 horizontal brace at -25 feet has 6 inch by 8 inch by 1 inch deep dent, centered at 1 o'clock, 6 feet from face of leg A1).

2. **Provide a database for archiving and querying key information related to a fleet of platforms.** For the MMS this would be all platforms in US OCS waters. For an operator this would be the specific platforms operated by the company (Table 1-1). The advantage of this database will be the ability to query the fleet information on topics such as platforms inspected within the last year, platforms with known damage, platforms within a particular location (perhaps in the path of an on-coming hurricane) and other types of queries. The program will be structured so that just about any type of query is possible.

3. **Provide a means for first order platform strength estimates.** At this time, complex structural analysis are often used to evaluate platform strength. However, there are some simpler approaches that can provide a "first order" estimate of strength. The program will contain a module for performing such evaluations. The

procedure can be used to rapidly assess a large group of platforms and "screen" out (i.e. identify) the lower strength platforms that should receive first attention. The procedure can also be used on specific platforms to see if more complex analysis is required. The simpler approaches could also be used to identify "weak links" and "weak zones" in the platform structure, which can provide a basis for an operator for planning inspections and structural assessments.

4. **Provide an interface between inspection results and structural assessments.** Most offshore inspection information can be difficult and tedious to apply to structural integrity assessments. The data must be sorted and condensed to determine which of the information will actually affect structural integrity. It is often difficult to determine which member is actually damaged, the extent of the damage and the precise location. The program will provide an interface between the inspection results and structural analysis program that automates and simplifies conversion of inspection data to useful data for structural analysis.

5. **Provide a framework for reporting inspection and assessment information to the MMS.** At this time inspection information must be reported to the MMS. In addition, the MMS may also request structural integrity assessments of some platforms (e.g. seismic assessment of older platforms located offshore California.) The program will provide a framework for producing such reports.

2.2 OPERATIONAL REQUIREMENTS

The previous section described the technical capabilities of the program. Operational requirements refer to the general approach and features that should be built into the program. These operational requirements are defined as follows:

1. **Provide a system acceptable to and usable by regulators and industry.** The project will be completed using joint industry participation using combined input from regulators and industry. The input from various participants also ensures use of the best available technology.

2. **Use existing technologies as much as possible.** Technologies such as AIM (Platform Assessment, Inspection and Maintenance), CAP (structural analysis) and CAIRS (inspection database) currently address some of the issues of existing platforms and should be used to the fullest extent possible. This reduces costs and takes full advantage of existing, proven technologies.

3. **Interface with other programs.** CAP and CAIRS were selected as base case programs since they are used by the MMS in platform evaluations. However, recognizing the need of operators who do not currently use these programs, OPES will also be able to interact with other programs such as SACS (Engineering Dynamics Inc.) and STRUDL (MIT). The operator may have to modify an existing program to be compatible with OPES. In addition, note that OPES will be able to operate without the use of any external program, however, some capabilities such as detailed inspection archiving and detailed structural analysis will be limited.

4. **Provide for expandability.** The system is designed to be expandable for adding new modules (e.g. inspection planning) and interfacing with other software (e.g. reliability software such as RELACS).

5. **Utilize state-of-the-art software.** The program will use the latest software technology including advanced database applications and a graphical user interface.

This will help ensure that the system is as useful, up-to-date and easy to use as possible.

6. **Maximum hardware flexibility.** The program will be compatible between several computer systems. Users operating the program in a stand-alone mode will be able to operate the system effectively on readily available PCs. The program will also be able to interface with more powerful computers, such as a SUN workstation, used for structural analyses.

2.3 KEY COMPONENTS

The original plans for development of this type of system involved direct communication between several existing programs, such as CAIRS for database and inspection information and CAP for structural analysis. Upon further investigation, it was determined that additional programs would be needed to obtain all of the required capabilities. A more extensive database was required to store the many types of platform evaluation criteria and a "screening" program was required to perform rapid structural integrity evaluations. In addition, the system must remain flexible for future expansion and interfacing with other programs.

Figure 2-1 shows how a system composed of individual but compatible programs would operate. The system requires separate interfaces between all of the programs. Clearly, this will involve a significant effort in developing several unique interfaces between each program. Further, new programs that can interact with the system will also require development of unique interfaces to each of the other programs.

An alternative is to restructure the system so that the platform database is the central source of communication between all of the programs. This concept is shown in Figure 2-1, and is called OPES for Offshore Platform Evaluation System. OPES is a much improved arrangement since the platform data is sorted in a "central database" that stores and transfers data between each of the auxiliary programs. This arrangement requires modification of each program to provide only a single interface to the central database. Once a program is modified to be compatible with the central database it will be compatible with other programs linked to the system. This ensures a high degree of compatibility at low cost and with a much improved capability for future expansion.

Figure 2-2 shows that there are six key components in OPES – a central database, an historical information interface, an inspection interface, a structural analysis interface, a program for platform screening (first order strength estimates) and an interface for future programs. The remainder of this section provides a brief summary of the capabilities of each component. Detailed descriptions and proposed capabilities for each of these OPES components can be found in indicated sections of this document.

2.3.1 Central Database (Section 3)

The central database is the core of the program. It will serve as the archive center for all information and will interface with the other programs. The primary functions of the central database are:

- **Archive/manage data.** Key data related to the platform will be archived. There will be two levels for the database. The first level will describe the platform fleet. This will contain key information about each platform in the fleet such as type of platform, water depth, number of legs, last date inspected, known damage, etc. The second level will provide detail information about each of the individual platforms such as number of piles, number of conductors, overall geometry, etc.

Information can be input via interface with an existing program (e.g. CAIRS) or inserted manually.

- **Interface with other codes.** The database will be the central point for communication between programs. Data will be passed to the database, archived and then converted and transmitted to other programs as required. For example, inspection information may be available from CAIRS. Key information, such as damaged member and extent of damage, will be sent to the central database for archiving. This information can then be distributed to other modules for use elsewhere, such as structural analysis using CAP.

- **Data queries.** A number of data queries can be performed for a fleet of platforms. The query can also be of several levels. For example, a query for the platform fleet may read - identify all platforms installed before 1975 that were inspected within the last year where damage was found that reduced the reserve platform strength by more than 20 percent. Just about any combination of queries will be possible with the user selecting from a list of options.

- **Reports.** Different levels of report generation will be possible. Inspection and assessment summary and detail reports can be generated in a format suitable for submittal to the MMS (since the MMS will be involved in development of the report format). Reports providing summary or detailed information for management or engineering purposes will also be available. The user will be able to customize any report.

2.3.2 Platform Historical Data (Section 4)

Historical information related to the platform can be input to the database via connection with an existing database computer code. For example, the MMS maintains a summary database of all offshore platforms located in OCS waters as previously shown in Table 1-2. This database contains information such as platform operator, name, year installed, location, water depth, etc. This information can be directly read into the OPES database as an initial starting point. Additional information can then be added from other programs or via manual input. In the case of a single platform, there may be a series of Computer Aided Design Drafting (CADD) files available from previous work. In this case, OPES will interact with CADD via a generic interface to obtain geometric information such as nodal coordinates and member sizes. This option may only be possible with certain types of CADD files. The intent of this feature is to use as much existing digital data as possible to build the OPES database. In some cases there will be little or no data (digital) available describing a platform and it will have to be input manually.

2.3.3 Inspection Data (Section 5)

Inspection database programs will be able to transmit information to the central database. The base case program will be CAIRS. Other programs (e.g., MMS inspection database) will be able to interact with the database as well via a generic interface, but they may require some form of modification. CAIRS (or a similar program) will pass key information to the central database such as any damage found in a particular inspection. Typically, only data which impacts structural integrity will be stored in the central database. The central database will also store a chronology of key results from previous inspections that can be used to help track crack growth, anode depletion, etc. The user will be able to access CAIRS or another inspection database if additional detailed information on an inspection is required (diver logs, photos, etc.).

2.3.4 Structural Analysis (Section 6)

Structural analysis programs will be able to interact with the database and exchange information. The base case program will be CAP. Other structural analysis programs such as, SACS or STRUDL, will be able to interact with the database as well, but they may require some form of modification. Platform geometry and member sizes can be extracted from the database to provide an initial starting point for development of a structural computer model. Likewise, information available from existing structural computer models (platform geometry and member size) can be transmitted to the central database for use in other programs. Key results of structural analyses can also be stored in the central database for use in other programs (e.g. a future reliability module) or report documentation.

2.3.5 Platform Screening (Section 7)

A procedure for a rapid first order structural assessment of a platform will be beneficial for screening many platforms to prioritize structural assessments and determine an estimate of potential problems. It will also be beneficial to prioritize inspection of specific zones of selected platforms among a fleet of platforms owned by an operator. Several screening-type procedures have been postulated but few have been implemented in practice. This particular task will develop first order structural assessment procedures and then implement the procedures into a computer code that is compatible with the central database.

2.3.6 Future Interfaces (Section 8)

As noted previously, one of the key features of the central database is that all information will be available in a central location and in a specific format. This allows for easy communication between compatible programs and provides a simple format for extension of the program's capabilities. This enhances the ability to add future interfaces to the program. An example is a platform reliability program which uses information such as environmental return period information combined with the platform's reserve strength to determine the level of safety offered by the platform structure. Another example is an inspection planning program which uses information from the central database, such as key results from the last inspection, plus critical platform members identified via structural analysis to help specify details (i.e. when, where and how much to inspect) of future inspections. Finally, OPES may eventually interface with a similar program (or an extended OPES) that includes assessment and safety information related to the platform topsides.

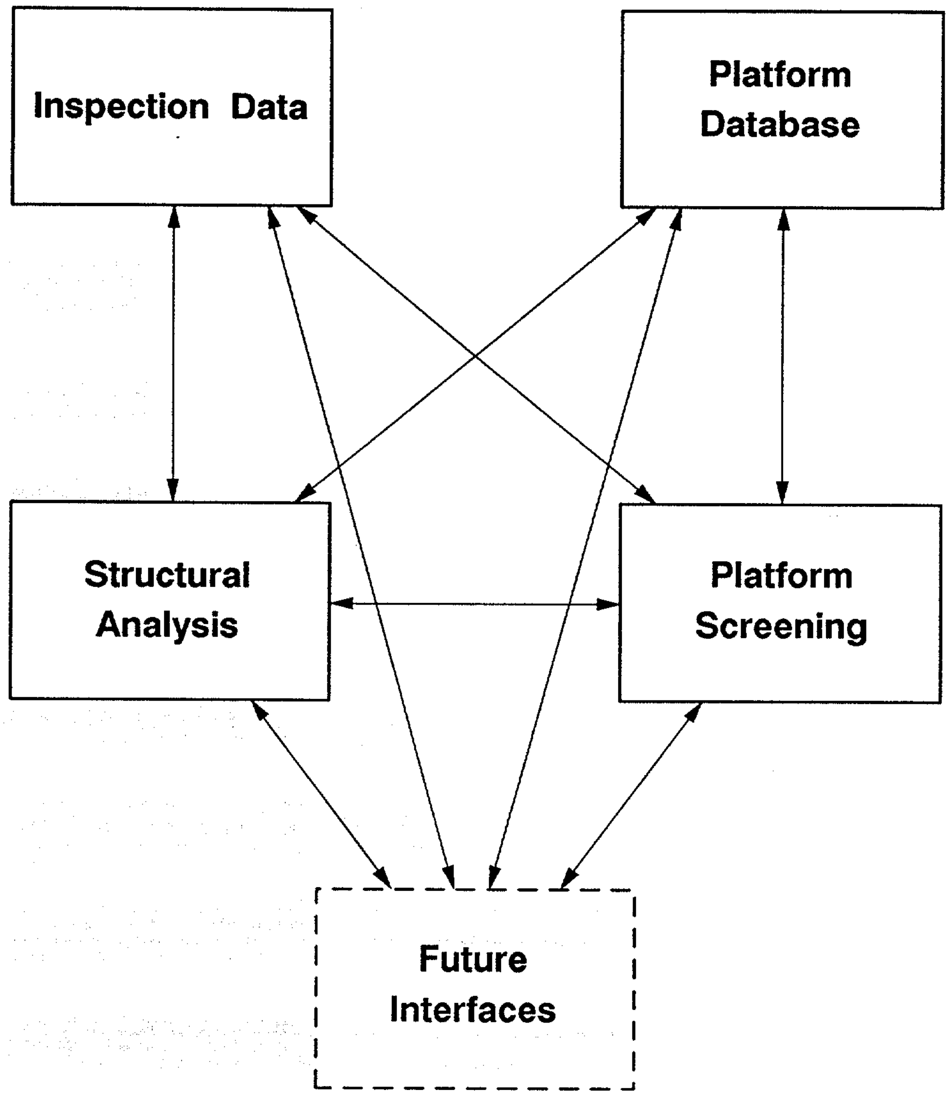


Figure 2-1 INDIVIDUAL INTERFACES BETWEEN PROGRAMS

.031\OPES\FIG-2-1

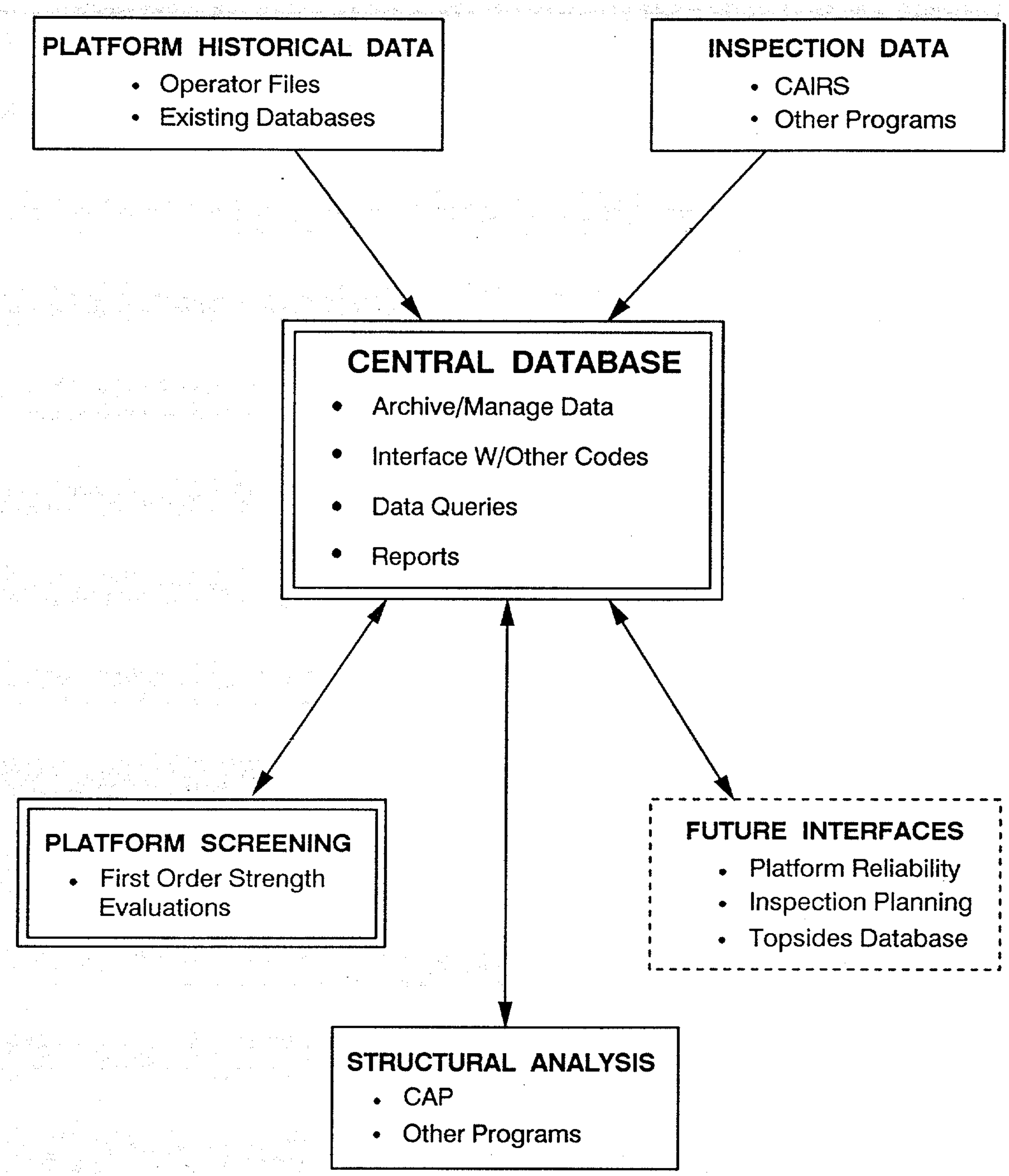


Figure 2-2 OPES - A CENTRAL DATABASE SYSTEM

.031\OPES\FIG-2-2

Section 3
Central Database

3.1 OBJECTIVES

The central database will archive data, perform data queries, transfer data between programs (e.g. CAIRS to CAP) and generate reports. The database is structured to store information necessary for a structural integrity assessment of a platform.

3.2 PLATFORM FLEET DATABASE

The platform fleet database contains "status" information that can be used for planning or review purposes. The database reflects only the current condition of the platform, for example, a summary of damage that has not yet been repaired. Once the damage is repaired (and perhaps approved by the MMS), the specific damage would not be indicated. If the user is interested in the specific damage, it can be found in the single platform database described below. The fleet database is essentially a shortened version of the single platform database described below. All information contained in the fleet database is also available in the single platform database.

Table 3-1 shows a preliminary listing of the platform fleet database. A numbering system helps identify and track the various subsets of data. This is a preliminary listing that will be further detailed and expanded in future phases of the project.

3.3 SINGLE PLATFORM DATABASE

The single platform database contains detailed information about a specific platform. It is used to store both current and historical data. For example, key information related to all of the inspections of the platform (versus just the last inspection provided by the fleet database).

Table 3-2 shows the general categories of information contained in the central database with further information contained under each category. Each of the categories are summarized in the following sections. A numbering system helps identify the various subsets of data. Similar to the fleet database, this is a preliminary listing that will be further detailed and expanded in future phases. Appendix A lists all of the central database information.

3.3.1 General Platform Data (Table 3-3)

This database contains background information on the platform. The **Platform Description** identifies the platform ID, owner, designer, etc., as well as the type of platform and general configuration. The **Age Data** helps identify the platform vintage and the anticipated remaining service life. The **Upgrades or Revisions** contains a chronological listing of each upgrade or revision including a brief description. A detailed description of each upgrade or revision is also included.

3.3.2 Structural Data (Table 3-4)

This database contains structural information required for strength assessments and is divided into two sections – jacket and deck.

The **Jacket Data** includes the jacket proper, foundation, conductors, appurtenances, corrosion protection and damage. Not every detail of the jacket geometry or members will be included, since a more detailed description is available by interfacing with other programs such as CAP. The intent is to store enough information (i.e. node location, member size/thickness) to visually display the structure on OPES screens and provide the beginnings of a structural computer model via interface to other programs.

The **Deck Data** includes the deck structure, equipment (summary only), appurtenances and structural damage. The equipment data is intended for use in determining dead/live and wind loads on the deck. For both the jacket and the deck the damage data is summary information of known damage that impacts strength.

3.3.3 Site Data (Table 3-5)

This database contains the site information used to determine the environmental loads acting on the platform and the foundation conditions. The database contains **Location Data, Meteorologic-Oceanographic Data, Geotechnical Data, Seismic Data,** and **Other Data** (e.g. ice and original design criteria). The original design criteria provides a reference point for the as-built design and is useful to determine the types of structural integrity problems that may exist for the platform.

3.3.4 Inspection Data (Table 3-6)

This database contains inspection results pertinent to structural assessment of the platform. The **Inspection Chronology** provides an historical record of inspections performed on the platform. The **Summary Results** provide results of previous inspections which impact structural strength (such as cracks and dents). This is a duplicate of that contained in the structural database previously described. The **Detail Results** provide additional details of previous inspections via interface to CAIRS (or other another inspection database program) where a complete description of the inspection is available. **Inspection Plans** indicate future planned inspections for the platform (e.g. 6/92, 6/95).

3.3.5 Strength Data (Table 3-7)

This database contains key assessment results pertinent to determining structural integrity. The strength database is structured similar to the inspection database and includes **Assessment Chronology, Summary Results,** and **Detail Results.** The **Assessment Chronology** provides an historical record of previous assessments performed on the platform. The **Summary Results** provide key results of previous assessments such as platform ultimate capacity and RSR. As described later in Section 6, results from a sequence of strength analyses performed over several years can be used to trigger detailed inspections or remedial work. The **Detail Results** provide additional detail of the assessment (computer model, type of analysis, load profile, etc.) via interface with CAP (or another analysis program) where complete description of the assessment is available.

3.4 QUERIES

The database will be structured so that just about any type of data query can be made for the platform fleet. The user will select from a list of search criteria that can be combined in any sequence or order. The user would select a particular item, say platforms installed before 1970 and, if desired, combine this with additional queries such as water depth or owner. The program would then sort the database and identify all platforms that meet the selected criteria. Table 3-8 provides several examples of the types of queries that will be possible.

3.5 INTERFACE WITH OTHER PROGRAMS

The database will interface with other programs. This allows use of existing data as much as possible and transfer of information between programs. Obviously, different programs will require different interfaces. However, "built-in" interfaces will be available for CAP to exchange data related to structural models and structural assessment results (see Section 6), and CAIRS to transfer inspection results (see Section 5). Another interface will be built for the Platform Screening program to be developed as part of OPES.

Other interfaces may also be developed for example to CADD programs to read platform geometry information, to other structural analysis programs (SACS, STRUDL), to other inspection programs, or to additional data processing programs (RELACS, PROBAN). The number and extent of interfaces will depend upon participant direction during OPES phases.

3.6 REPORTS

The database information will be reportable in a variety of formats. Default reports will provide either summary or detailed information. The user will also be able to customize reports. The exact content and format of the reports will be determined during the course of the project. Several examples of default reports are as follows:

1. **MMS Inspection Reports.** There is a current requirement to report results of inspections to the MMS. The inspections are typically performed according to API RP 2A guidelines (API, 1992). Results are typically submitted to the MMS in a variety of formats and levels of detail. Using input from the MMS and industry participants, an inspection report format will be developed and included in OPES.

2. **MMS Assessment Reports.** In some cases the MMS may require a strength assessment of a platform. Similar to the inspection report, the format and content of this report would be mutually defined by the MMS and participants.

3. **Management Summary Reports.** This type of report will summarize key information about the current status of a fleet of platforms or a single platform. In the case of a platform fleet, this report may include a number of built-in data queries that help portray the current status and areas of concern with the fleet.

4. **Detailed Reports.** Any level of detail can be contained in this report. The user will select different levels of detail to be reported. For example, all detail except for jacket node locations. For another report, the user may want only the node locations. Virtually any combination of data can be included in the report.

Table 3-1
Platform Fleet Database

100	Background Data	
	105	MMS complex ID number
	110	Platform number
	115	Platform name
	120	Location (block or area)
	125	Operator
	130	Platform type (production, drilling, quarters, etc)
	135	Year installed
	140	Original design life
	150	Type of production (oil, gas)
	155	General configuration (4-pile, 8-pile)
	160	Number of wells
	165	Manned/unmanned
200	Structural Data	
	205	Number of legs
	210	Number of horizontal elevations
	215	Joint cans (yes/no)
	210	Number of piles
	215	Min/max pile penetration
	220	Legs/piles grouted (yes/no)
	225	Number of existing conductors
	230	Deck elevation
300	Site Data	
	305	Water depth
	310	Distance form shore
	315	Design wave height
	320	Reference wave height (e.g. API reference height)
	325	General soil type (soft clays, silts, etc)
	330	Seismic zone (1, 2, 3, 4)

Table 3-1
Platform Fleet Database (Continued)

400	Inspection Data	
	405	Last date of inspection
	410	Type of last inspection (API Level 1, etc.)
	415	Existing unrepaired dents/holes
	420	Existing unrepaired bent members
	425	Existing unrepaired cracks
	430	Existing unrepaired flooded members
	435	Existing corroded members
	440	Existing other damage
	445	Number of CP readings below limit
	450	Percent of anode depletion
500	Strength Data	
	505	Last date of strength evaluation
	515	Platform capacity
	510	Number of overstressed members
	520	Platform reserve strength ratio
	525	Distance deck is above or below design wave
	530	Probability of platform failure
	535	Number of members with fatigue life below allowable

Table 3-2
Single Platform Database — General Categories of Data

1000 General Platform Data

- 1100 Platform Description
- 1200 Age Data
- 1300 Upgrades and revisions

2000 Structural Data

- 2100 Jacket Data
- 2200 Deck Data

3000 Site Data

- 3100 Location Data
- 3200 Meteorologic-Oceanographic Data
- 3300 Geotechnical Data
- 3400 Seismic Data
- 3500 Other Data
- 3600 Original Criteria

4000 Inspection Data

- 4100 Inspection Chronology
- 4200 Summary Results
- 4300 Detail Results (CAIRS)
- 4400 Inspection Plans

5000 Strength Data

- 5100 Assessment Chronology
- 5200 Summary Results
- 5300 Detail Results (CAP)

Table 3-3
General Platform Data (1000)

1100 Platform Description

1105 Platform ID – (e.g. Ship Shoal 199-A)
1110 Owner
1115 Block or Area (e.g. Eugene Island)
1120 Original designer
1125 CVA
1130 Platform Type (Production, Drilling and Production, Quarters, Transfer Station, Storage, Other)
1135 Structure Type (Conventional Fixed Base, Caisson, Tripod, Cook Inlet, TLP, FPS, other)
1140 Manned/unmanned (identify number of personnel)
1145 Number of Wells
1150 Evacuation Methods (boat, helicopter)
1155 Helideck Size (or none)
1160 Type of production - oil/gas
1165 Production Rate - bbl/day

1200 Age Data

1205 Date Installed
1210 Original design life
1215 Current estimate of remaining field life
1220 Number of wells
1225 Original Design Basis (RP2A Edition, Lloyds, other certification basis)

1300 Upgrades or Revisions

1305 Upgrade Chronology
1310 Date
1315 Descriptive Short Name (e.g. Strengthened piperack)
1320 Detailed Description (memo)

Table 3-4
Structural Data (2000)

2100 Jacket Data

2105 Jacket

2105.05 3-dimension coordinates of all nodes
2105.10 Tubular member sizes (20" dia 5/8" wall thick, etc.)
2105.15 Unusual jacket members, if any (AISC W or T Shapes, etc.)
2105.20 Joint cans – length and wall thickness
2105.25 Material type – A36, A537, etc. Mil cert data if available.
2105.30 Intentionally flooded members
2105.35 Weld details (i.e. profiled, ground)

2110 Foundation System (Piles assumed)

2110.05 General Type – leg, skirt
2110.10 Number of piles
2110.15 Location of each pile – Leg A1, Leg B1, Leg C1 – 3 skirt piles, etc.
2110.20 Diameter, wall thickness and schedule – by pile
2110.25 Material type – A36, A537, etc. Mil certs if available
2110.30 Original pile design penetration
2110.35 Actual Penetration depths – by pile, per driving records or estimated
2110.40 Pile connection – welded/grouted

2120 Conductors

2120.05 Number
2120.10 Sizes (26" dia, 3/4" wall thick, etc.)
2120.15 Material type – A36, A537, etc. Mil cert data if available.

2130 Appurtenances (item, location and size)

2130.05 Walkways, barge bumpers, boat landings, stairways, etc
2130.10 J-tubes and risers

2140 Corrosion Protection

2140.05 Type – anode/impressed current
2140.10 Number and location of anodes
2140.15 Coatings or sheathing (monel)

Table 3-4
Structural Data (Continued)

2150 Damage

- 2150.05 Dents
  - 2150.0505 Location – distance from leg, circular location (degrees or time coordinate)
  - 2150.0510 Size – diameter, length, depth
- 2150.10 Cracks
  - 2150.1005 Type – partial or thru crack
  - 2150.1010 Location – circular location (degrees or time coordinate)
  - 2150.1015 size – length
- 2150.15 Holes
  - 2150.1505 location (similar to dent)
  - 2150.1510 size – diameter and length
- 2150.20 Flooded Members
  - 2150.2005 Members checked
  - 2150.2010 Members flooded
- 2150.25 Corroded Members
  - 2150.2505 Members checked
  - 2150.2510 Members with severe corrosion (less than same threshold levels, e.g., 60 percent or original thickness remains)
- 2150.30 Other damage

2200 Deck Data

2210 Structure

- 2210.05 3-dimension coordinates of all nodes
- 2210.10 Tubular member sizes (20" dia 5/8" wall thick, etc.)
- 2210.15 Other Deck Members (AISC, W, or T Shapes, channels, etc.)
- 2210.20 Joint cans – length and wall thickness
- 2210.25 Material type – A36, A537, etc. Mil cert data if available.

Table 3-4
Structural Data (Continued)

2215 Equipment Information

2215.05	Deck dead and live loads from original design. Also need relative geometry of all equipment to compute wind loads.
2215.10	Actual deck loads based upon deck survey. All structures and equipment including buildings, drill rigs, pipe racks, mud tanks, etc.
2220.15	Special concerns such as hook loads and localized loads from cranes, flarebooms, bridge to adjacent structure, etc.

2220 Structural Appurtenances (item, location and size)

2220.05	Drill rigs
2220.10	Flare Booms
2220.15	Bridges
2220.20	Other

2225 Damage (Structural)

2225.05	Dents	
	2250.0505	Location – distance from leg, circular location (degrees or time coordinate)
	2250.0510	Size – diameter, length, depth
2225.10	Cracks	
	2250.1005	Type – partial or thru crack
	2250.1010	Location – circular location (degrees or time coordinate)
	2250.1015	size – length
2225.15	Holes	
	2250.1505	location (similar to dent)
	2250.1510	size – diameter and length
2225.20	Corrosion – material loss on members	
2225.25	Other damage	

Table 3-5
Site Data (3000)

3100 Location Data

- 3105 General Region – Gulf of Mexico, California, Alaska, etc. based upon some type of MMS classification. Signifies the general type of concern for platform – e.g. GOM – hurricanes.
- 3110 Lease/Tract number – Ship Shoal 199
- 3115 Coordinates
- 3120 Orientation
- 3125 Miles from shore

3200 Meteorologic – Oceanographic Data

- 3205 Water Depth for design – MLW plus tide plus surge
- 3210 Design wave height and period
- 3215 Design current
- 3220 Random seas, etc. that may be needed for compliant-type structures
- 3225 Primary hydrodynamic loading directions
- 3230 Marine growth (as function of depth)
- 3235 General wave environment (e.g. Wave height/current versus return period for the site)
- 3240 Other criteria (Operating conditions, Fatigue)
- 3245 Design Wind Speeds
- 3250 Air Temperature Extremes (for Arctic applications)

3300 Geotechnical Data

- 3305 General type (soft clays, stiff clays, silts, sands, etc.)
- 3310 Soil profile – soil layers and engineering properties
- 3315 Strength profile (strength versus depth, if available)
- 3320 Pile-soil strength curves (p-y and t-z, if available)
- 3325 Other special soil issues (e.g. - mudslide zone)

3400 Seismic Data

- 3405 Strength level data – strength level spectra
- 3410 Ductility level data:
  - 3410.05 Ductility level spectra
  - 3410.10 Ductility level time history (e.g. scaled Loma Prieta)
- 3415 General seismic environment (e.g. peak ground acceleration versus return period)
- 3420 Deck spectra

Table 3-5
Site Data (Continued)

3500 Other Data

3505 Ice – ice strength, ice thickness, ice loading scenarios (sheet ice, rafted ice, ice impacts), etc.

3600 Original Criteria – Original environmental design criteria, if available (e.g. wave heights, C_d, C_m, soils, etc.)

Table 3-6
Inspection Site Data (4000)

4100 Inspection Chronology

- 4105 Date
- 4110 Descriptive Short Name (e.g. yearly inspection, inspection following large hurricane, etc.)
- 4115 Performed By (Oceaneering, etc.)
- 4120 Further Written Detail (memo)

4200 Summary Results

- 4205 Jacket Damage
  - 4205.05 Dents
    - 4205.0505 Location – distance from leg, circular location (degrees or time coordinate)
    - 4205.0510 Size – diameter (width), length, depth
  - 4205.10 Cracks
    - 4205.1005 Type – partial or thru crack
    - 4205.1010 Location – circular location (degrees or time coordinate)
    - 4205.1015 size – length
  - 4205.15 Holes
    - 4205.1505 location (similar to dent)
    - 4205.1510 size – diameter and length
  - 4205.20 Flooded Members
    - 4205.2005 Members Checked
    - 4205.2010 Members Flooded
  - 4205.25 Corroded Members
    - 4204.2505 Members checked
    - 4205.2510 Members with severe corrosion (less than same threshold levels, e.g., 60 percent or original thickness remains)
  - 4205.30 Other damage
- 4210 Deck Damage
  - 4210.05 Dents
    - 4210.0505 Location – distance from leg, circular location (degrees or time coordinate)
    - 4210.0510 Size – diameter, length, depth

Table 3-6
Inspection Data (Continued)

4210.10 Cracks
- 4210.1005 Type – partial or thru crack
- 4210.1010 Location – circular location (degrees or time coordinate)
- 4210.1015 size – length

4210.15 Holes
- 4210.1505 location (similar to dent)
- 4210.1510 size – diameter and length

4210.20 Corrosion – material loss on members

4210.25 Other damage

4220 Other Findings

4215.05 Measured Marine Growth Profile
4215.10 Cathodic Protection (average CP readings and any CP readings below limit, percent depletion of anodes)
4215.15 Bottom Survey (summary of debris and scour)
4215.20 Risers (riser or clamp damage
4215.25 Photos/Videos Available (summary list of whats available via interface with CAIRS)

4300 Detail Results – Interface with CAIRS or other inspection database program

4400 Inspection Plans

4100 Next Scheduled Inspection
4200 Descriptive name for inspection (e.g. per MMS requirements)
4300 Further Written Detail

Table 3-7
Strength Data

5100 Assessment Chronology

- 5105 Date
- 5110 Descriptive Short Name (e.g. Static pushover, Dynamic pushover, quick check following boat impact damage, etc.)
- 5115 Performed By (Operator, PMB, etc.)
- 5120 Further Written Detail (memo)

5200 Summary Results

- 5205 Type of evaluation – unity check, capacity check, both.

- 5210 Unity check
  - 5210.05 Number of members overstressed per design criteria
  - 5210.10 Detail of overstressed members plus their unity check

- 5215 Capacity check
  - 5215.05 Platform capacity (kips, etc.)
  - 5215.10 Load-deformation curve (global shear vs deck deflection)
  - 5215.15 Return period of wave causing platform failure
  - 5215.20 Distance wave is above or below deck at failure
  - 5215.25 Reserve Strength Ratio
  - 5215.30 Probability of platform failure

- 5210 Fatigue check
  - 5220.05 Lowest fatigue life for any member
  - 5220.10 Number of members with fatigue life below allowable

5300 Detail Results – Interface with CAP or other structural analysis program

Table 3-8
Example Queries

1. Identify pre-API RP 2A platforms:

   Query: – Installed before 1969

2. Identify higher risk pre-API RP 2A platforms:

   Query: – Installed before 1969
   – Manned
   – Oil Producing

3. Identify platforms recently inspected using API Level II-VI:

   Query: – Last inspection < 1 year
   – API Level II or greater

4. Identify platforms with decks exposed to wave impact

   Query: – Deck is below design wave height

5. Identify higher risk platforms in path of oncoming hurricane:

   Query: – Located in Eugene Island or Ship Shoal
   – Installed before 1975
   – Manned
   – Existing unrepaired damage
   – RSR less than 1.5

Section 4
Historical Platform Data

4.1 OBJECTIVES

Data describing the platform's "historical" background must be input to the central database. The specific types of data have been previously described in Section 3. The historical data can be in the form of hardcopy documents or digital database-type information.

Hardcopy data includes drawings and reports. There is little choice with this type of data format and it will have to be manually reviewed with the necessary data extracted and manually input to the data base. However, some of this data may already exist in digital format, such as newer platforms installed after 1980, or in the case of some of the larger operators. Digital data such as structural computer models may also be available from recent structural analysis of a platform required for upgrades or reassessment. Generally, the digital information will be available from in-house databases, structural computer models, or special purpose computer programs.

The objective of this portion of OPES is to provide a facility to use as much existing digital data as possible. This type of facility reduces labor and costs associated with manually imputing data. It also makes the best use of software previously developed by an operator and allows the operator (if desired) to maintain both systems in parallel (perhaps with different objectives) with the ability to exchange data between the systems as required. It also reduces the chance of input errors by using previously digitized data (i.e. no human intervention).

4.2 TYPES OF DATA

The types of information available for a platform can be divided into hardcopy and electronic information.

Hardcopy data for existing platforms may consist of structural drawings, design reports, site data, CVA documentation, and inspection reports with limited (if any) digital information. For some platforms there may be virtually no data and the platform will have to be defined based upon site inspections. In either case, if only hardcopy data is available, then the operator will have to extract the necessary data from available documentation and manually input it to the central database. OPES will be equipped with a data input facility structured to simplify this process.

Digital data may be available from several sources as follows:

1. **Operator Database.** An operator may have an existing in-house database that stores relevant platform information. This type of database may not necessarily contain all of the information storable within OPES, but it will provide a useful starting point. As an initial starting point, the MMS database described in Section 1 and shown in Table 1-2 will be installed in OPES.

2. **Inspection Programs.** Inspection information about the platform may be stored in an inspection program, such as CAIRS. Results of inspections are available from this type of software, and in some cases, perhaps platform geometry or member information.

3. **Structural Analysis Programs.** A structural computer model of a platform provides detailed information related to platform deck/jacket/foundation geometry and individual member sizes and properties. As previously described in Section 3, some general structural data such as geometry (nodal coordinates) and member diameter/thickness are stored in the central database. In this case, the information may be taken directly from existing structural computer models, although as

described below, an interpreter will be required to modify the information from the computer model format to the database format.

4. **Design Assistance Programs (CADD).** Computer aided design drafting (CADD) is used in many newer platform designs. It may also have been used to design upgrades to an existing platform. CADD can provide platform geometry and member information.

5. **Specialized Programs.** An operator may have other specialized programs (i.e. 123 spreadsheet files) that can be used to transfer information to the database. Examples of these types of programs may include cost estimating databases or material/weight management programs.

4.3 INTERFACE WITH OTHER PROGRAMS

4.3.1 Database Programs

A direct "all purpose" interface with operator databases will be difficult since most of the databases will be user specific containing unique formats and types of data. Therefore, either custom built interfaces will have to be constructed or the operator database will have to export the information into a specific "generic" format that is readable by the central database. Since a custom interface for each operator is beyond the scope of this JIP, the central database will be developed so that it can read information directly from an external generic file of specific format.

4.3.3 Inspection Programs

The inspection interface provides up-to-date information on the condition of the platform. OPES will be designed with a full interface with CAIRS. Interface with other inspections programs may also be included depending upon participant interest. Further details regarding this type of interface are described in Section 5.

4.3.2 Structural Analysis Programs

Interface with structural analysis programs can be difficult due to the variety of structural analysis programs, although there is some existing precedent. For example, CAP has the capability of reading SACS and STRUDL files. This is an important and time saving feature since structural models are available for many platforms. OPES will be designed with a full interface with CAP making CAP structural models fully compatible with the central database.

A generic interface will be available to read data information from other structural analysis programs. This will require the structural analysis program to output the model and results in the specified generic format. This may require modification of the structural analysis program or independent development of an interpreter to evaluate and rearrange the structural model to the generic format required by the central database. Depending upon participant direction, OPES can be equipped with the ability to read structural computer models from other programs than CAP. Further details regarding interface with structural analysis programs are described in Section 6.

4.3.4 CADD

This type of interface is difficult since many CADD-type programs are structured to display a graphical representation of a platform versus the logic-based description and connectivity of a platform required by the database and used in structural analysis programs. For example, a CADD drawing may show a particular frame of a jacket and have as callouts the size of the frame and individual member sizes. However, the CADD program does not store "logical" information that links member location, geometry (length) and size (diameter/thickness), rather it stores a variety of lines, line weights and alpha-numeric callouts that are specifically arranged on the drawing to visually display the platform. This differs from the central database which requires 3-dimensional nodal coordinate information, with members located between nodes (hence defining their location and length) and members identified with specific diameter and thickness.

Some CADD programs have this capability if 3-dimensional imaging options are used which require a more logical definition of the platform geometry and connectivity so that the platform can be rotated and viewed from different directions. Unfortunately, this is a newer technology and much of the existing platform related CADD information is likely stored in the older format. An investigation into type of CADD drawings typically available and the amount of effort associated with development of a CADD interface will be part of the Phase II work.

4.3.5 Specialized Programs

Similar to operator databases, specialized operator software will have to be independently modified to write information into a specific generic format suitable for the central database. Examples of specialized software include spreadsheet files (e.g. Lotus 123, Microsoft Excel, etc.) or special purpose analysis, costing estimating, or material/weight management programs. The spreadsheet files can be easily modified by the user to write data to the generic format by using spreadsheet macros. Other special purpose programs are typically written by the operator and can therefore be readily modified to write data to the generic format.

Section 5
Inspection Data

5.1 OBJECTIVES

Inspection data is used to update the central database to account for the current known condition of the platform. Inspection data is typically in the form of reports and drawings which summarize procedures and results of on-site above and underwater inspections. In some cases a computer program such as CAIRS is used to store the data and produce inspection reports.

The objective of this portion of OPES is to provide an interface with inspection programs like CAIRS. The inspection interface serves two purposes:

1. **Data Transfer**

   Transfer of key inspection results to the central database. The intent is to automate as much as possible the transfer of useable inspection data to the central data base for eventual use by other programs. The primary inspection data stored in the central database will be the location and extent of known platform damage such as holes, dents and cracks, that can later be transferred to a structural analysis program to determine how the damage affects platform strength.

2. **Detailed Inspection Information**

   The inspection program such as CAIRS can be accessed for detailed inspection data not typically stored in the central database. Examples include inspection operation and equipment details such as vessels used, number of divers, cathodic protection (CP) half-cells, MPI equipment, available pictures and video, etc., as well as details of inspections not typically used in structural analysis, such as CP surveys, bottom surveys, riser/conductor surveys, etc.

This section describes the requirements for an inspection interface. The CAIRS program is used as an example of a typical inspection database program to describe the proposed capabilities, use and problems associated with this interface. The current plan is to use CAIRS as the base case inspection program that will be 100% compatible with OPES. Other inspection programs may be included depending upon participant direction.

5.2 TYPES OF DATA

The types of inspection data necessary for platform assessment have been previously described in Section 3 and are repeated here as Table 5-1.

5.3 INTERFACE WITH CAIRS

5.3.1 Data Available from CAIRS

CAIRS is used to store results of platform inspections and produce inspection reports. Appendix B provides a detailed description of CAIRS.

A summary of the types of inspection data stored by CAIRS is shown in Table 5-2. Review of this table indicates that, if properly used, CAIRS can supply most of the necessary inspection information for the central database (Table 5-1).

The general categories of data that are useable by the central database are as follows:

- **General Platform Data.** Platform name, location, water depth, etc., can be input to the central database directly from CAIRS. Thus, if an operator has been using CAIRS to maintain inspection records, then CAIRS can be used to initially load this type of information to the central database in an automated fashion.

- **Structural Data.** Ideally, existing CAIRS inspection records could also be used to input platform geometry and member information to the central database. Unfortunately, CAIRS contains only a general description of the platform geometry, (i.e. number of legs and elevations) which is not sufficient for the 3-dimensional data required by the central database. CAIRS does have a link to CADD which provides the capability to view the platform on-screen if CADD drawings are available; however, as described in Section 4, 3-dimensional structural data required by the central database is difficult to obtain from typical CADD files.

- **Damage Data.** CAIRS contains detailed records of most types of damage (known as defects in CAIRS) such as bent members, cracks, holes and dents. As described in Section 5.3.2, some interpretation is necessary to convert the CAIRS damage data, such as location and description of dents or holes, into the structural analysis format required by the central database.

Note that detailed inspection data not contained in the central database will be available via link to CAIRS. The link to CAIRS may be used, for example, to determine specific CP readings at different regions of the platform, or to determine the inspection firms or the types of MPI equipment used in previous inspections.

5.3.2 Data Format

General platform data available from CAIRS is easily transferable to the central database. The information need only be converted to the proper digital format to be read by the central database.

Structural data available from CAIRS, as noted above, is not in a 3-dimensional structural analysis format and will not be directly transferrable directly to the central database. CAIRS does not currently have sufficient platform configuration information to warrant an interpreter to convert the information to a structural analysis format for later use in building structural computer models. Future upgrades or revisions to CAIRS may make this type of data more readily available to the central database.

Damage data available from CAIRS is the key information required by the central database. The intent is to use the damage data to upgrade analytical structural models of the platform to determine the effect of the damage on structural integrity. This requires the information in the proper format that allows analytical modeling of the damaged members. However, the description of damage data supplied by an inspection/diving firm typically differs from the description of damage required for structural analysis, creating several problems in transferring data as described in the following paragraphs.

There are four basic types of typical member damage that are of concern. The first is dents caused by falling objects, impacts from supply vessels or damage during transport or installation. The second is holes caused by corrosion or in some cases falling objects. The third is bent members, which are often found in combination with dents or holes, and are also caused by falling objects or vessel impacts. The last and perhaps most common is cracks, usually caused by fatigue, accelerated fatigue-corrosion or perhaps in some cases by member overstress. Other damage is of course possible, but these four types cover most damage conditions.

Figure 5-1a shows the types of data required to describe dents or holes for use in analytical structural models (PMB, 1991, Moan and Taby, 1985). Two types of data are required. The dent/hole must first be located on the platform structure. This requires identification of the member, distance along the member, and location of the dent relative to the member's circumference. Once located, the dent/hole is further defined in terms of length, width and depth.

Similarly as shown in Figure 5-1b, a bent member requires identification of the bent member, followed by the distance along the member to the approximate center of the bend and then the bend eccentricity.

Figure 5-2a shows the types of data required to describe a crack or cracks. The member/joint or "node" is first identified along with the affected chord and braces. The crack location along the circumference of the joint and the crack length are then determined. Finally, "local" information about the crack is required such as location relative to the weld (chord or brace side) and crack depth (partial or through crack). In many cases the crack depth is unknown without further extensive testing. In this case, the conservative through crack condition is often assumed for analysis purposes. Figure 5-2b shows the similar types of information required for a joint member with more than one crack.

CAIRS inspection records typically contain the types of data required to define damage; however, in the field and particularly underwater, these measurements are not as direct and straightforward, and are therefore not always recorded in this manner. For example, divers use a local reference frame such as distance from a principal leg or distance inboard or outboard to reference damage locations. The dent/hole location may be measured in terms of time coordinates such as a dent extending from 10:30 o'clock to 1:00 o'clock. The result is that CAIRS stores damage data in a different format from that required by the central database.

There is obviously enough logic contained in the CAIRS reference system to build an interpreter to convert inspection results to a format suitable for the central database reference frame. The interpreter can be contained within CAIRS or OPES, although CAIRS is the most suitable location for several reasons. First, the inspection results must be reported in a proper and consistent reference frame, which is not always the case in the field. In order to ensure proper and consistent reporting, the CAIRS input screens and prompts can be slightly modified to ensure that all damage is reported using the correct reference frame. Second, existing inspection results may need review and modification to ensure results have been recorded in the proper reference frame. This process will be more efficient if the interpreter is self-contained within CAIRS, and indeed Solus Schall is currently studying the feasibility of this feature.

For some types of damage, a set of rules will have to be developed which describe how the damage should be measured and recorded. For example, Figure 5-3 shows several examples of cracks that are not as easily located and defined. The figure shows how cracks extending away from the joint, multiple cracks at a complex joint and cracks at overlapping joints can cause difficulties in establishing the exact location and extent of a crack. A portion of the Phase II work will be a study of the typical types of damage and the development of some standard description and measurement techniques that can be used to define the damage in a computerized format.

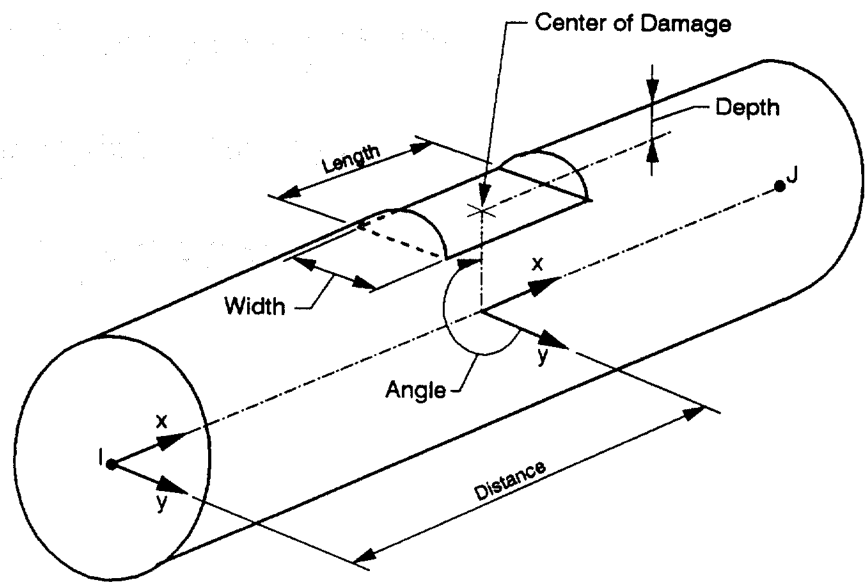
Similar to inspections, the cracks shown in Figure 5-3 are not as easily defined in analytical models. Complex 3-dimensional finite element shell analysis or fracture mechanics based analysis can be used to determine the impact of the crack on joint strength, but this type of analysis is generally beyond the scope of most platform evaluations. More typically, the user may make some conservative estimates of the capacity of the damaged joint and then use this in a structural CAP type computer analysis. This is the type of approach proposed for OPES, where the user will perform analysis of such cracks off-line (via analytical models or specialized analysis) and then use CAP or another analysis tool to determine the impact on platform capacity.

In summary, the CAIRS interface will provide a mechanism for updating the central database with the latest inspection results. The inspection results will be in a format suitable for use in structural analysis; however, this will require some modification to CAIRS in terms of data input and a format interpreter to ensure that the damage is properly defined for use in structural analysis.

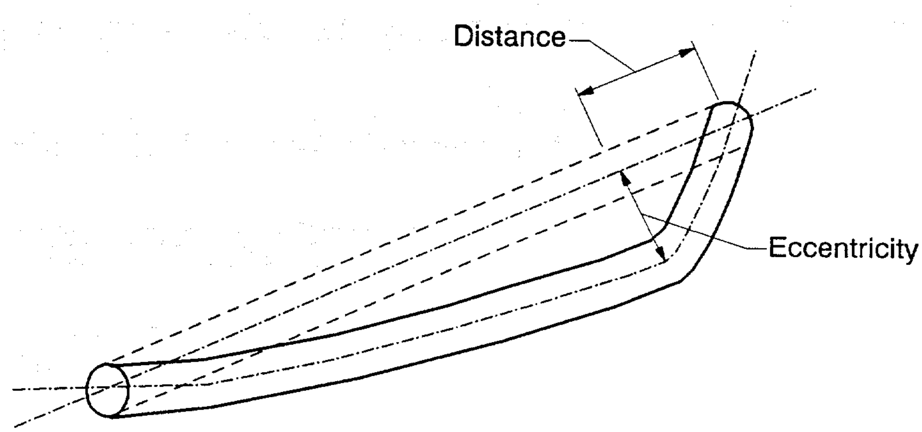
5.4 INTERFACE WITH OTHER INSPECTION PROGRAMS

Interface with other inspection programs will be possible, although the same type of data format problems (i.e., damage descriptions) that have been described for CAIRS are also applicable to other inspection programs. OPES will be designed to interface with any other inspection program via a "generic" interface containing a specified set of data and format. This may require modification of the inspection program to provide information in the generic format.

The central database can also be designed to directly interface with other specific inspection programs (like CAIRS) if required by participants. Similar to CAIRS, the inspection program would have to have an interpreter so that it provides information to the central database in a "structural analysis format."



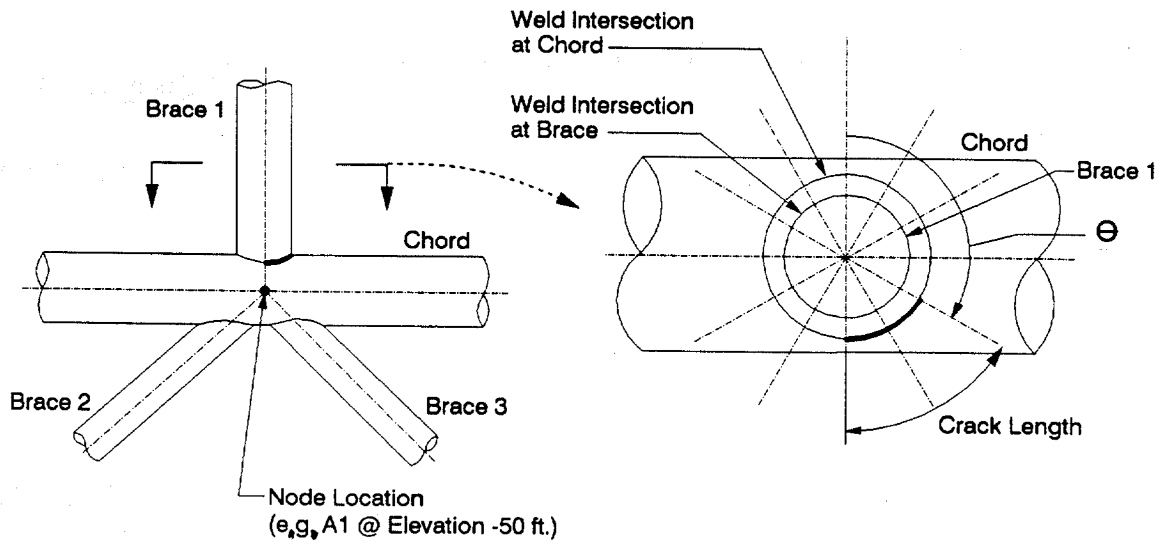
a) Dent or Hole Definition



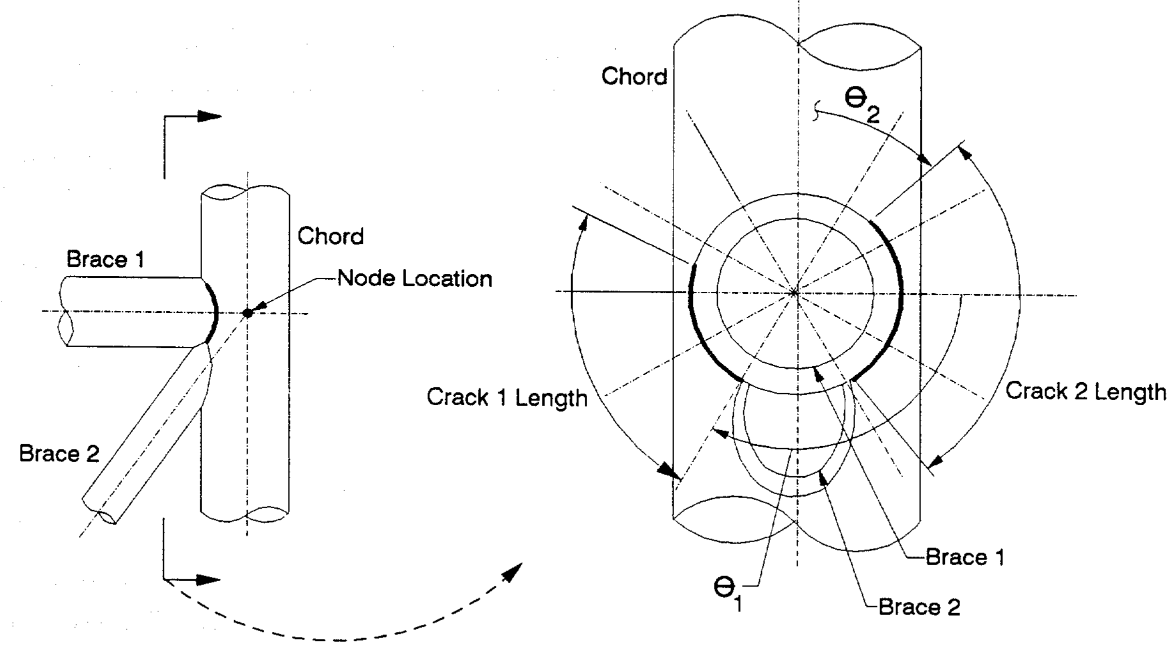
b) Bent Member Definition

Figure 5-1 Location and Dimension Information Required for Analytical Model of a Dent, Hole or Bent Member

.031\OPES\FIG-5-1



a) Single Crack



b) Multiple Cracks

Figure 5-2 Location and Dimension Data Required for Analytical Model of a Typical Joint Crack

.031\OPES\FIG-5-2

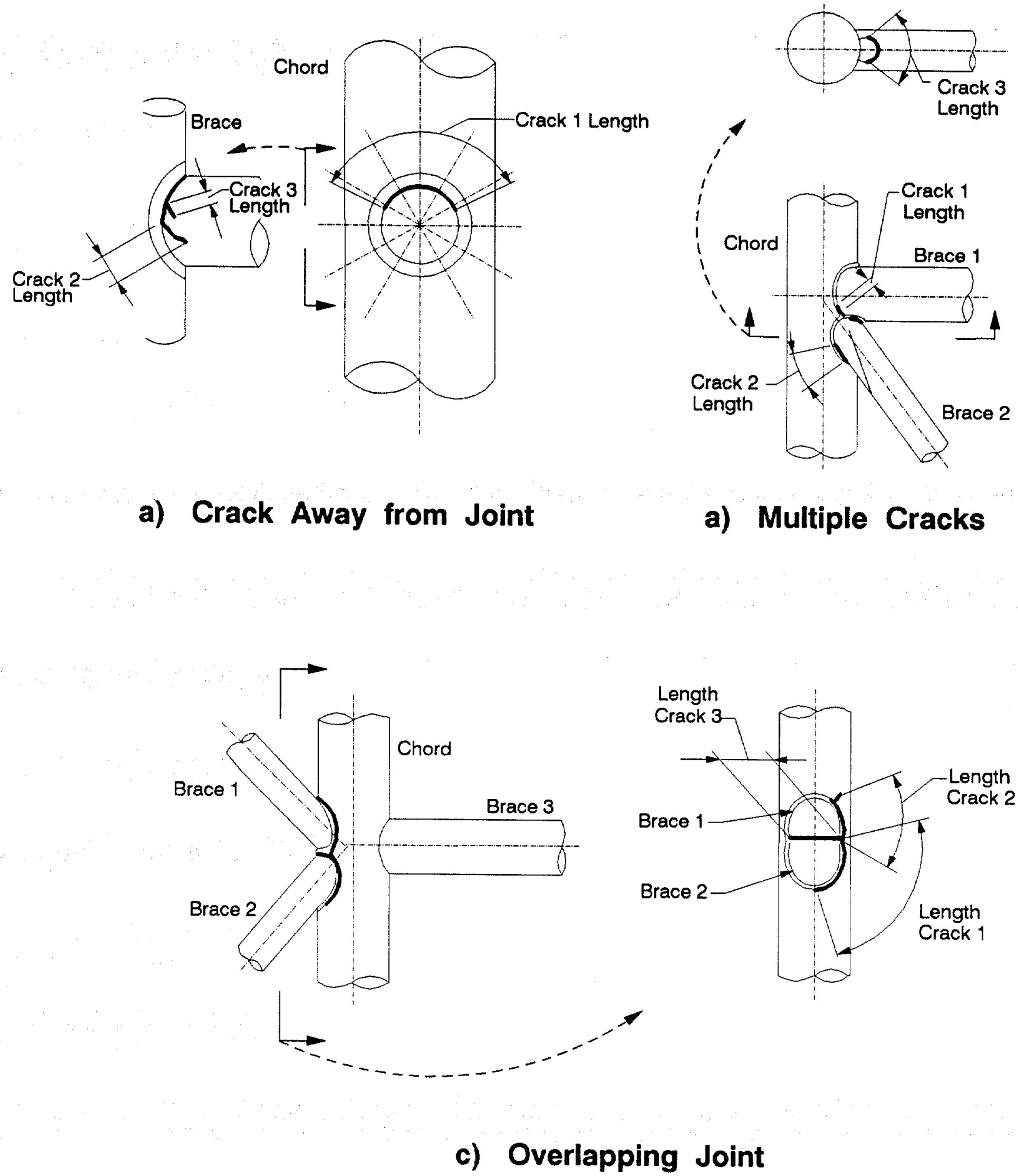


Figure 5-3 Examples of Complex Cracks

.031\OPES\FIG-5-3

Table 5-1
Inspection Data Stored in Central Database

4100 Inspection Chronology

- 4105 Date
- 4110 Descriptive Short Name (e.g. yearly inspection, inspection following large hurricane, etc.)
- 4115 Performed By (Oceaneering, etc.)
- 4120 Further Written Detail (memo)

4200 Summary Results

- 4205 Jacket Damage
  - 4205.05 Dents
    - 4205.0505 Location – distance from leg, circular location (degrees or time coordinate)
    - 4205.0510 Size – diameter (width), length, depth
  - 4205.10 Cracks
    - 4205.1005 Type – partial or thru crack
    - 4205.1010 Location – circular location (degrees or time coordinate)
    - 4205.1015 size – length
  - 4205.15 Holes
    - 4205.1505 location (similar to dent)
    - 4205.1510 size – diameter and length
  - 4205.20 Flooded Members
    - 4205.2005 Members Checked
    - 4205.2010 Members Flooded
  - 4205.25 Corrosion – material loss on members
  - 4205.30 Other damage
- 4210 Deck Damage
  - 4210.05 Dents
    - 4210.0505 Location – distance from leg, circular location (degrees or time coordinate)
    - 4210.0510 Size – diameter, length, depth

Table 5-1 Inspection Data Stored in Central Database (Continued)

4210.10 Cracks
- 4210.1005 Type – partial or thru crack
- 4210.1010 Location – circular location (degrees or time coordinate)
- 4210.1015 Size – length

4210.15 Holes
- 4210.1505 Location (similar to dent)
- 4210.1510 Size – diameter and length

4210.20 Corrosion – material loss on members
4210.25 Other damage

4220 Other Findings
- 4215.05 Measured Marine Growth Profile
- 4215.10 Cathodic Protection (average CP readings and any CP readings below limit, percent depletion of anodes)
- 4215.15 Bottom Survey (summary of debris and scour)
- 4215.20 Risers (riser or clamp damage
- 4215.25 Photos/Videos Available (summary list of whats available via interface with CAIRS)

4300 Detail Results – Interface with CAIRS

4400 Inspection Plans
- 4100 Next Scheduled Inspection
- 4200 Descriptive name for inspection (e.g. per MMS requirements)
- 4300 Further Written Detail

Table 5-2
Inspection Data Available from CAIRS

Platform Description: Background data describing the structures such as lease number, platform type, year installed, no. of legs/piles/conductors/slots/risers, horizontal framing elevations, MMS complex ID. no., etc.

Inspection Description: Background data describing the particular inspection such as start/end dates, contractor, company representatives, vessel name, etc.

Damage Descriptions: Bent member crack, hole and dent descriptions such as location, orientation, dimensions, member and leg diameters, and wall thicknesses. Further descriptions are available describing detailed visual and MPI surveys on selected nodes, including descriptions of welds (profile and dimension) and any defects (pitting or cracks) and any repairs performed such as grinding or holes drilled to arrest crack growth.

Marine Growth Survey: Type, thickness and estimated percentage cover at various points on the platform.

Cathodic Protection (CP): CP readings in negative millivolts taken at various locations around the structure. Basic statistics (low, high and mean) available. All readings below a threshold lower limit are noted.

Bottom Survey: Depth readings at the base of the structure, the bottom type (surface soils) and the presence and measurement of any scour, deposition, mudmats or bottom debris.

Riser Survey: MMS segment number, location, size, type, coatings, tube turn, status, wall thickness, and damage to risers. Clamp conditions including visible damage and any missing or loose bolts. Pipeline status including damage, length and distance off bottom of any spans, length exposed and wall thickness.

Topside: Overall integrity of the topside structural and coating conditions. Presence of damage, ratings of structural and coating conditions for all topside compoennts. Erosion/corrosion wall thickness data for process equipment.

Photo and Video Logs: Digitized photographs and list of all photographs and videos taken during the inspection.

Section 6
Structural Analysis

6.1 OBJECTIVES

Structural analysis plays a key role in assessing structural integrity. It is used to determine a platform's capacity which provides a measure of the platform's ability to resist environmental loadings. OPES is structured to interface with structural analysis codes via a direct interface with CAP or a generic interface with other structural analysis programs.

The structural analysis interface has three objectives:

1. **Transfer of Structural Analysis Results**

   Transfer of key structural analysis results to the central database.

2. **Update Structural Analysis with Inspection Results**

   Inspection data stored in the central database can be transferred to the structural analysis program to update computer models. The combination of inspection results and structural analysis can also be used in planning further inspection and remedial work.

3. **Provide Detailed Structural Analysis Data**

   A link with the structural analysis program (e.g., CAP) allows access to the detailed results of any previous structural analysis.

6.2 TYPES OF DATA

The types of structural analysis data necessary for platform assessment has been previously shown and is repeated here in Table 6-1. The central database will only store the key results of previous structural analysis and will not store all of the detail such as types of computer elements used, load profiles, analysis solution strategies, etc. This type of detailed is available directly from the analysis program (e.g., CAP).

6.3 INTERFACE WITH CAP

6.3.1 Data Available from CAP

The two general types of data available from CAP are shown in Table 6-2. The first is structural configuration information such as 3-dimensional nodal coordinates, member connectivity and member sizes. As previously described in Sections 3 and 4, this data can be read and stored by the central database in the Structural Data database (Table 3-4). The information is used on-screen by OPES for graphical representations of the platform. It can also be transferred to other programs for use in others types of analysis.

The second type of data is analysis results. At this time, CAP provides most of the straight forward results of analysis, such as identification of members failing unity checks and platform capacity, required by the central database and shown in Table 6-1.

Data required by the central database (Table 6-1) and not available directly from CAP includes the return period (RP) associated with the failure wave, distance that the failure wave crest is above or below deck elevation, and probability of platform failure. Theses are all "computed" values that require further manipulation of the analysis results beyond that typically performed by a structural analysis program.

The failure wave RP provides a general indication of the level of safety for the platform (i.e. platform will not collapse under a 100 year RP wave). This evaluation requires site specific wave height versus return period data, and data which correlates global wave forces (or platform capacity) with wave heights. Based upon these two relationships, a global wave force (or capacity) versus return period correlation can be made. This data is then used to determine the return period of the failure wave based upon the platform's capacity. At this time, CAP has no return period versus wave height information, but this could be easily added. OPES also has a location for this information in the Site Data (Table 3-5, Item 3235). The wave force versus wave height relationship is developed by running a series of waves of different heights past a CAP model of the platform and recording the maximum base shear for each wave. The development of this information can be performed either within CAP or OPES, although additional data storage will have to be added to OPES for the wave force versus wave height relationship.

The distance that the design wave is above or below the deck is another general indication of the platform's safety. The distance is computed by subtracting the deck elevation from the wave crest elevation (computed via a wave theory such as Stream Function) with a positive value indicating the wave impacts the deck and a negative value indicating the wave crest is below the deck. CAP contains both of these pieces of information and can be easily modified to compute the required value. Alternatively, CAP can transfer the wave crest elevation and the deck elevation to the central database with the computation performed there.

The probability of platform failure is often taken as the inverse of the RP of the failure wave. This type of computation is also easily performed in either CAP or the central database. In other cases, a more exact evaluation of the probability of failure may be developed using more exact methods such as FORM or SORM computations performed by external reliability programs (see Section 8).

Although CAP or OPES can be used to perform these additional computations, the best location is within OPES. This provides the greatest amount of flexibility in terms of interaction with other structural analysis programs which most likely will also lack the necessary "computed" data. In addition, some of the data that must be stored in central database may be useful for other programs. For example, the wave force versus RP data may be useful to an external reliability program.

6.3.3 Data Sent to CAP

An important feature of OPES is the transfer of damage information to a structural analysis program to update computer models of the platform. Damage data is first sent to the central database from the inspection program such as CAIRS. Alternatively, the user can input the damage data directly to the central database. The inspection data is then transferable to the structural analysis program.

Section 5.3 has previously described the types of damage data available and the issues involved in describing and storing the data in a format suitable for structural analysis. Since the data is stored in a structural analysis format it can be easily transferred to CAP. Once within CAP the program will update the structural model accordingly to account for the damaged members. This process is not currently available within CAP or is known to exist in any other structural analysis program, but can be added. A part of this process may require the user to identify the reduced capacity of the damaged member "off-line" from the CAP program. For example, Brace Buster (PMB) or DENTA (Moan and Taby, 1985) may be used for this purpose. Alternatively, CAP has a super element which can segment the damaged brace and add the proper reduced cross-section which accounts for the member damage. In this case, a near fully automated process could be developed. The level of automation required for CAP or other structural analysis codes will be determined during the next phase of the OPES project.

6.3.3 Example Use of Strength and Inspection Data

Inspection data can be used for more than just updating the central database and structural computer model. For example, strength results can be used in combination with inspection results to track the structural integrity of a platform and to determine if and when different levels of inspections and/or remedial repair are required. OPES will be structured to easily provide several combinations of this information.

Table 6-3 shows an example use of combined inspection-strength data for a hypothetical platform. The table shows results of inspections and results of subsequent simplified "screening" (Section 7) analyses and detailed CAP analyses. The first three annual inspections indicate minor damage with RSR determined according to simplified methods (screening). The fourth inspection indicates significant damage and the associated screening analysis indicates a low RSR of 1.1 which in this example is the threshold level identified by the particular operator for performing more detailed inspections and analysis. The fifth inspection is more detailed and focuses on the damaged area with results input to a more sophisticated nonlinear analysis using CAP. The CAP analysis indicates that the platform's RSR is not as low as indicated by the simplified screening analysis but is still low enough to warrant repair of the damaged section. A detailed CAP analysis is performed using the repaired platform configuration and indicates that the platform's capacity is again at an acceptable level. The operator elects to perform Level II annual inspections for the next few years to ensure no damage recurrence.

This example illustrates how inspection and strength data can be combined to assist in platform evaluations. Several of these types of useful features will be developed and implemented in OPES.

6.3.4 Data Format

All of the CAP data is compatible with the format required for the central database. The two data types shown in Table 6-2 – background information and analysis results – are easily transferable.

6.4 INTERFACE WITH OTHER STRUCTURAL ANALYSIS PROGRAMS

Interface with other structural analysis programs will be possible provided the programs can export information suitable for input to the central database. This will likely require modification of the existing structural analysis program. The central database can be modified to interact directly with structural analysis programs other than CAP if desired by participants.

Note that CAP has an existing interface to SACS and STRUDL. Therefore, operators with CAP can transfer SACS and STRUDL information to the central database via CAP.

Table 6-1
Strength Data Stored in Central Database

5100 Assessment Chronology

- 5105 Date
- 5110 Descriptive Short Name (e.g. Static pushover, Dynamic pushover, quick check following boat impact damage, etc.)
- 5115 Performed By (Operator, PMB, etc.)
- 5120 Further Written Detail (memo)

5200 Summary Results

- 5205 Type of evaluation - unity check, capacity check, both.
- 5210 Unity check
  - 5210.05 Number of members overstressed per design criteria
  - 5210.10 Detail of overstressed members plus their unity check
- 5215 Capacity check
  - 5215.05 Platform capacity (kips, etc.)
  - 5215.10 Load-deformation curve (global shear vs deck deflection)
  - 5215.15 Return period of wave causing platform failure
  - 5215.20 Distance wave is above or below deck at failure
  - 5215.25 Reserve Strength Ratio
  - 5215.30 Probability of platform failure

5300 Detail Results — Interface with CAP or other structural analysis program

Table 6-2
Data Available from CAP

1. Platform Configuration (for use in Table 3-4)

   - 3-dimensional nodal coordinates
   - member connectivity
   - tubular member sizes – diameter/thickness/section properties
   - material strengths
   - foundation – pile sizes and penetrations
   - conductors – sizes and locations
   - pile connectivity – welded/grouted
   - deck elevation
   - deck configuration (typically primary members only)

2. Structural Analysis Results (for use in Table 6-1)

   - design wave conditions (height, period)
   - unity check results (overstressed members and location)
   - platform capacity
   - load-deformation curve
   - reserve strength ratio

Table 6-3
Example Use of Strength Results

Inspection No.	Inspection Type	Inspection Date	Key Inspection Result	Key Response Quantity (RSR)	Action
1	I	86	Minor Crack	1.5 (screening)	Reschedule Type I inspection
2	I	87	Minor Crack	1.5 (screening)	Reschedule Type I inspection
3	I	88	Moderate Crack Growth	1.4 (screening)	Reschedule Type I inspection
4	I	89	Significant Crack Growth	1.1 (screening)	Immediate Level III inspection. Detailed CAP analysis.
5	III	89	Crack	1.2 (CAP)	Joint Repair. Detailed CAP analysis
6	---	--	---	1.5 (CAP)	Reschedule Level II inspection

Section 7
Platform Screening

7.1 OBJECTIVES

The MMS as well as many operators have a large number of platforms that may require evaluation (see Table 1-1). A number of these platforms are of recent vintage, and if no significant structural damage exists, can be considered to have sufficient structural integrity since they were designed according to the latest codes and standards. Platforms such as this can be rapidly sorted from the central database according to factors such as API RP 2A edition used for design, installation date, design wave height, etc.

Other platforms are not as easily identified as having sufficient strength and therefore require some form of structural integrity check. The interface with CAP provides this capability; however, due to time and budget constraints, it may be difficult for the MMS or an operator to perform a detailed nonlinear analysis on each and every platform. Instead, a simpler procedure that provides a "first-order" estimate of platform capacity could be used to rapidly sort through the central database and "screen" out those platforms that may have inadequate strength. Platforms identified by the screening process could then be further evaluated using a more exact method, such as CAP, to determine the extent of concern. At this time there is no known platform "screening" program that provides these capabilities and can be interfaced with OPES.

The objective of this portion of the project is to develop a set of screening procedures for assessing platform structural integrity and implement the procedures into a computer program compatible with OPES. This particular feature was selected for development because even with just the central database and the screening program, the operator is provided with a useful first-order assessment capability.

7.2 SCREENING PROCESS

Two different types of screening are proposed. The first is a qualitative "Data Screening" that uses key physical, environmental and operational data related to a platform, such as date of installation or return period of design wave, and uses this data in a set of "rules" to determine if the platform's structural integrity is sufficient. The second is a quantitative "Computational Screening" that uses either load and resistance algorithms or simplistic structural analysis to determine the approximate platform capacity.

7.2.1 Data Screening

Many platforms can be eliminated from further evaluation based upon a qualitative review of key factors which influence the platform's loading or strength, such as the platform's age, deck elevation, geometric characteristics, design premises, etc. In addition, a qualitative review of the key operational data can be made to group platforms according to their importance, based on such factors as the production level, manned or unmanned, safety measures, etc. Most of these types of data are available from the central database, as previously described in Section 3. One concern is that the operator may not have available all of the required data (such as existence of joint cans) to enter in the database. However, as noted below, this problem can be accommodated within the screening process by making logical, conservative estimates if the data is not available.

Once the necessary information is retrieved from the database, the program will use a set of rules to determine if the platform has sufficient structural integrity. Table 7-1 provides a preliminary basis for preparation of such rules. In case a piece of data is not available, several existing pieces of data will be combined to establish a logical estimate of the missing data. For example, if it is unclear if a platform has joint cans, a logical estimate can be made based upon the date of installation (e.g. no joint cans if installed before 1969) or perhaps based upon the original operator or designer (e.g. operator A typically used joint cans, whereas operator B did not). If insufficient information is available to make a logical choice, then the rule will be defaulted to a conservative value (e.g., no joint cans).

This type of rule-based system is similar to an "expert" system, although the level of sophistication and rule basing used here will not be as extensive as typically used in full scope expert systems. Therefore, the procedure has been identified as data screening.

7.2.2 Computational Screening

The second screening method uses an analytical process to determine the platform's structural integrity. Two types of analytical processes are available. The first uses a simplified algorithm to make an approximate estimate of the force acting on and capacity of the platform. The second uses simplified linear structural analysis to make an improved estimate of the platform capacity. Each of these processes is described below.

The primary results of computational screening are some measure of the platform's ability to resist loading such as the reserve strength ratio (RSR). Once this information is determined, the MMS or operator must establish criteria, such as a minimum RSR, for identifying (screening) platforms with potential problems. Note that OPES is not intended to establish the threshold criteria; rather, it is a tool to perform the screening in an automated manner, with the definition of threshold criteria left up to the MMS or operator.

7.2.2.1 Algorithms

Forces acting on a platform and the capacity of a platform can be approximated using empirically based algorithms. Table 7-2 provides several examples of algorithms. As shown by these examples, the algorithms are formulated to make a relative assessment of the partial or full platform. The algorithms have empirical coefficients which account for specific features of the platform and site such as water depth, wave height, type of platform framing, deck elevation, etc.

One of the problems with algorithms is the diversity of offshore platform structural configurations and loading conditions that need to be considered. For some platforms, such as a four-leg platform in 100 feet of water, the algorithm may provide a reasonable estimate of platform loads and capacity. For other platforms, say an eight-leg structure with complex framing located in 500 feet of water, the algorithms may not be accurate even after the coefficients have been modified to reflect specific conditions for the platform. One alternative is to assign factors which indicate the degree of accuracy associated with the force or capacity estimate. The accuracy factors (or biases) would be based upon the differences in the analyzed platform configuration versus the "ideal" platform configuration used to develop and calibrate the algorithm. In this way, the user knows the relative accuracy of results and can use this information to determine if a more exact approach, such as simplified linear structural analysis (described below) or nonlinear structural analysis (e.g. CAP) is required. On the basis of such assessments, a need for further specific data for a platform can be established and an operator can allocate resources more effectively for inspecting specific platforms.

7.2.2.2 Structural Analysis

Simplified structural analysis provides an alternative procedure for determining structural integrity. Two formats for development of simplified structural analysis are described by Aggarwal (1991) and summarized below.

The first format is aimed at its application on a very large number of platforms. The first step is to divide the structure into a series of representative substructures as shown in Figure 7-1. This allows for evaluation of localized sections of the platform.

The second step is to determine approximate estimates of the upper and lower bounds of the capacity of each substructure. Figure 7-2 shows that for each of these substructures there exists a lower bound strength (capacity) defined by the load level corresponding to the first member failure in the bay, and an upper bound strength defined by the load level corresponding to the development of hinges in the piles/legs. Note that the load level exceeding lower bound strength in a substructure does not necessarily reflect platform failure, since the platform may have sufficient redundancy to incur additional loading and member failures prior to the development of a mechanism causing collapse. The upper bound strength clearly defines collapse because once several of the pile/legs have yielded in a substructure, there is no resistance to lateral loads. Note that collapse may actually occur at some lower load level between the lower and upper bound.

The third step is to determine the reference level loads acting on the platform, shown in Figure 7-2, as the API minimum reference level force (i.e. force determined according to API RP 2A recommendations). The reference load is determined according to environmental conditions (wind, wave, seismic) at the site and the platform configuration (projected area, hydrodynamic coefficients, platform mass (seismic), etc.). For wave loading, this process is generally straightforward with application of an appropriate wave theory to determine wave/current kinematics and use of Morison's equation to determine the local and global loads. For seismic loading, this process is more complex with the platform's mass serving as the most likely basis for developing the load profile, although this is currently being investigated in other studies (PMB, 1992).

The final step is to determine the structural integrity of the platform based upon comparison of the lower and upper bound strength of each substructure against the reference level force. Case A of Figure 7-2 shows a platform where the reference level force is below the lower bound strength, indicating that the platform will resist the reference level load, with a minimum reserve strength of R_u/S_r. Case B of Figure 7-2 shows a platform where the reference level load clearly exceeds the upper bound strength for at least one substructure, indicating that the platform will fail under the reference level loads.

By this method, the "weak link" (Most Likely to Fail – MLTF member) in the platform and the most critical substructure can be identified. The accuracy of the method depends upon an accurate identification of the failure modes and mechanisms for the platform and its components. An operator may use these results to focus further inspections/repairs on the critical MLTF members.

Aggarwal uses hand calculations to determine the force level and the lower and upper bound strengths for each substructure and make an assessment of the capacity of a platform. This type of evaluation can be incorporated into a semi-automated computer code. The required input for substructures strength evaluation would be the sizes and orientation of primary braces, legs, and piles. For OPES, it is recommended that such an analysis be performed for the platforms with inadequate data or without previously defined three-dimensional nodal and member data. The platform's general geometry and member sizes can be taken from the central data base, or if the information is not available, input directly by the user. Issues such as appurtenances and deck loads can be defined by the user according to a simplified format (e.g., input the wave load area of boat landing). Based upon such an analysis, a need for detailed linear or nonlinear structural analyses can be established.

The second format of simplified structural analysis would be to perform linear structural analysis using a scaled-down structural analysis code (e.g., CAP) based upon linear beam column elements. In this way, the load and capacity of platform can be established more accurately due to accurate formulation of the stiffness matrix and the lower bound strength for each substructure can be established. The upper bound strength for each substructure can be approximated by "system factors" evaluated from "rules" based upon physical characteristics of the substructures. Alternately, multi-cycle analysis with an assumed post-failure capacity of a member can be performed to establish successive failure of components. This process allows identification of the "weak zones" in the platform where multiple member failures can develop into a mechanism and eventual collapse. Similar to the "weak link", the "weak zone" is an area of the platform that should receive further attention from the operator.

Due to complex phenomenon of load shedding by an individual member upon its failure (i.e., buckled or yielded member) and load redistribution to other members, these simplified methods may not always provide an accurate estimate of the force levels at failure of each member and at formation of a mechanism. In these cases, the formation of mechanisms and the force levels corresponding to failure of successive components can be more accurately established by nonlinear analysis (CAP).

7.3 IMPLEMENTATION INTO SOFTWARE

7.3.1 Develop Procedures

Phase II of the project will develop the detailed screening procedures. The recommended plan for OPES is to follow and enhance the basic data and computational screening procedures outlined by Aggarwal (1991).

Some of the detailed topics to be considered are :

1. **Data Screening Rules.** Further identification and development of the types of data and associated rules that can be used for data screening. This particular portion of the project will benefit greatly from the joint industry format of the project since there will be plenty of "experts" and discussion to suggest and refine rules. This is important since the more input and experience incorporated in the rules, the better the rules and the better the screening process.

2. **Load/Resistance Algorithms.** Several algorithms have been developed as previously noted and shown in Table 7-2. If this is the preferred computational option (versus simplified structural analysis described below), these algorithms will provide an initial starting point for further development and incorporation into OPES.

3. **Simplified Structural Analysis Methods.** There are two formats for this option. The first is automation of the hand-calculation procedure by Aggarwal (1991) that uses simplified analytical techniques, based on general platform characteristics, to determine platform capacity. Capacity and loads are then compared to determine if the platform has sufficient structural integrity. The second is incorporation of a scaled down structural analysis code (e.g. CAP) based upon linear beam column elements. The geometry of the platform would be available from the central database or input separately to the screening module by the user. The linear analysis code would then perform the load and capacity analysis. Identification of first member failure would be simple (based upon first yield). Identification of the development of a mechanism at any substructure would be more difficult and may require "rules" for different types of bracing configurations or perhaps repeated analyses (i.e., with failed member eliminated or provided with reduced capacity)

to determine capacity. Similar to the first method, the load and capacity are compared to determine structural integrity.

7.3.2 Design Specification

A detailed design specification will be developed for this module prior to coding. The specification will identify the input and output screens for the module and describe how the module will interact with the central database.

7.3.3 Coding

Following development of the specification, and acceptance of the specification by participants, coding will commence on the module. Section 8 and Appendix C describe the overall OPES software development in more detail.

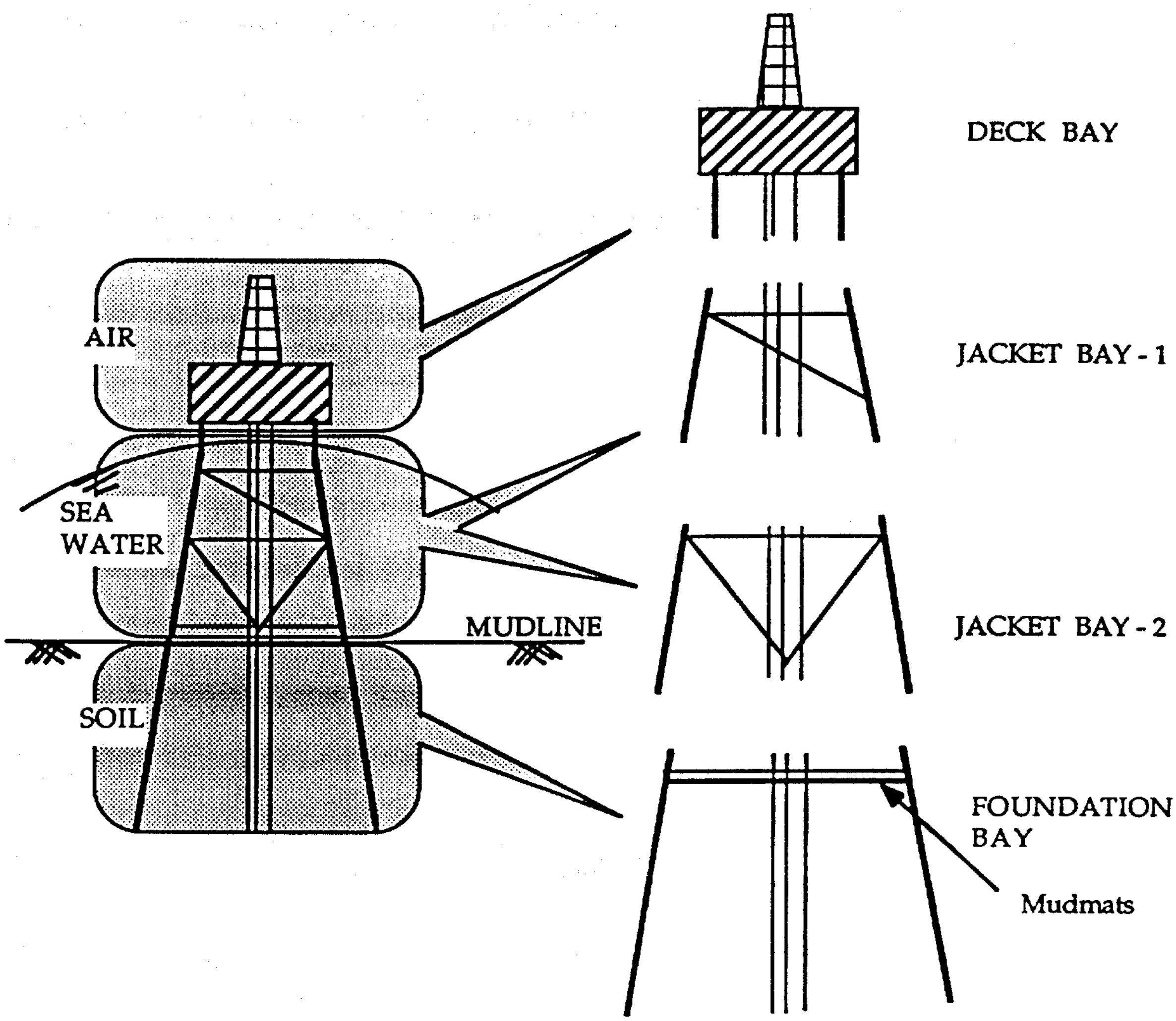
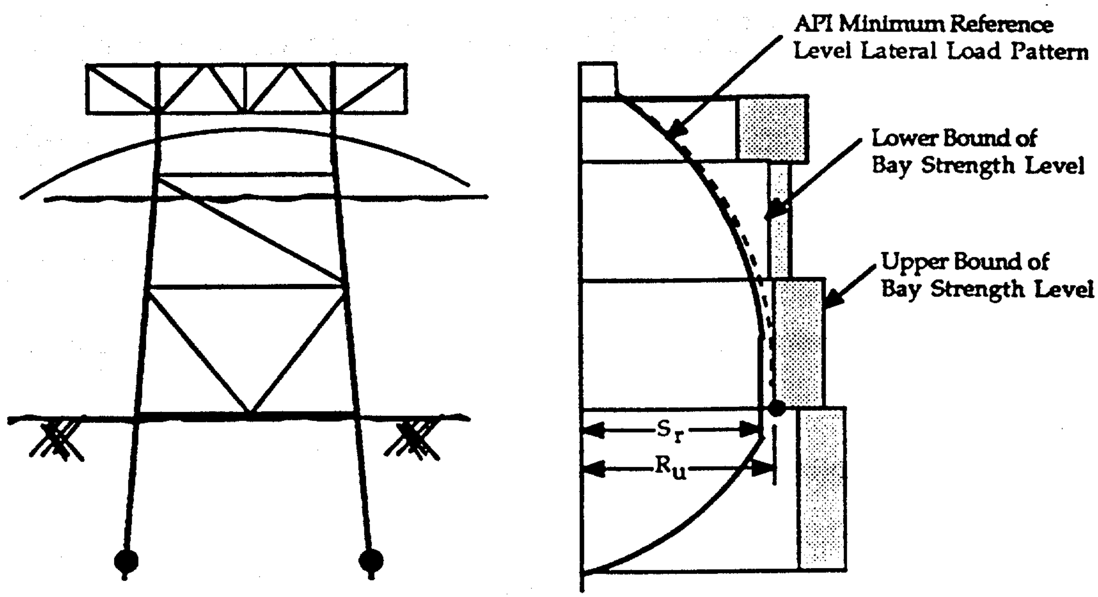
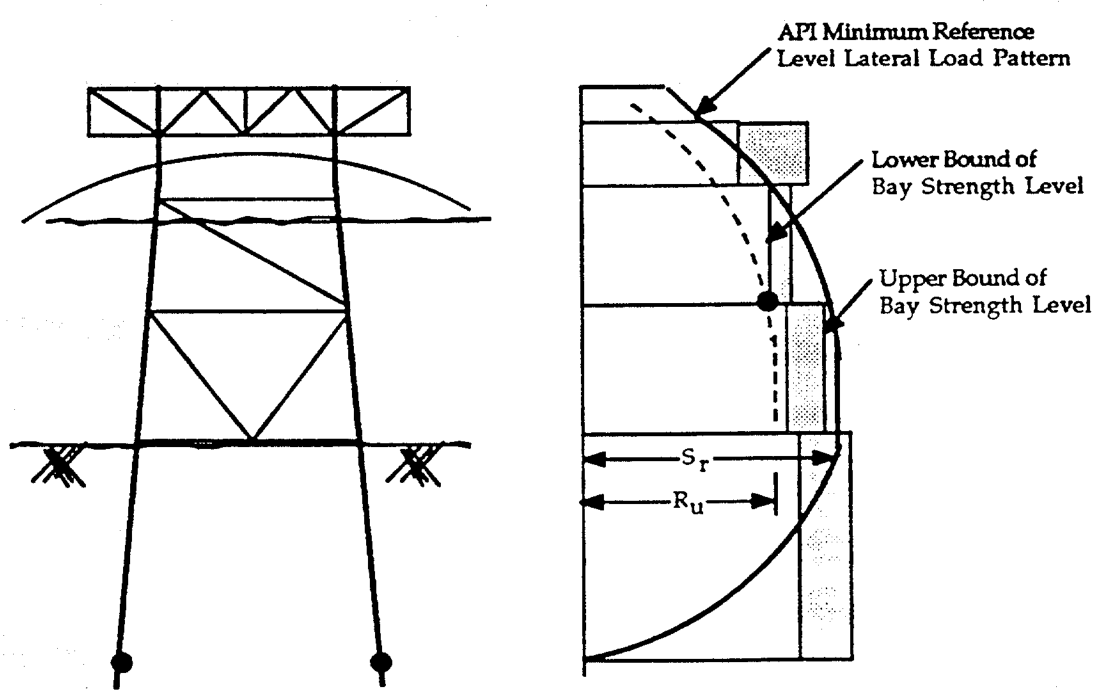


Figure 7-1 SUBSTRUCTURE FOR A STEEL JACKET PLATFORM (Aggarwal 1991)



Case - A: Reference Level Base Shear Pattern < Ultimate Strength Pattern



Case - B: Reference Level Base Shear Pattern > Ultimate Strength Pattern

Figure 7-2 SIMPLIFIED PLATFORM CAPACITY EVALUATION (Aggarwal 1991)

Table 7-1
Example Rules for Evaluating Existing Platforms

1. Was platform installed before 1970?

Early generation platforms suffer from a variety of problems including inadequate design criteria, lack of design codes, and poor joint detailing. Most platforms installed after about 1970 used the early API RP 2A recommendations as a design guide which greatly enhanced platform designs. Platforms installed prior to this time may have serious design deficiencies.

2. Is the platform manned or does it have significant oil production?

The key concerns offshore are loss of life and significant pollution. One method of screening is to focus on platforms with these attributes.

3. Does the API-reference level design wave hit the deck?

Due to significant differences in original design wave height and current API level wave heights, many older platforms had their decks set at lower elevations. During storms, large waves may impact the deck resulting in significant loads. Most platforms are not adequately designed or do not have adequate reserve capacity for this loading condition and may fail if a wave hits the deck.

4. Does the jacket lack joint cans or lack a grouted leg-pile?

One of the typical failure modes for older platforms is joint failure when compression braces punch through the legs. Newer platforms have thickened sections at joints to help prevent joint failure and increase platform capacity. A grouted pile-leg annulus also helps to improve joint capacity.

5. Does the platform have significant unrepaired damage?

Both older and newer platforms may suffer a loss of capacity due to damage such as cracks, dents and holes. Since an offshore platform typically contains redundant framing, the location and extent of the damage play a role in determining if there is a notable decrease in capacity associated with the damage. The definition of "significant" damage is the difficult part of this particular rule.

6. Was the platform designed by operator X or contractor Y?

For some older platforms, operator X or contractor Y typically used a particular set of design criteria or procedures that, although unknown at the time, resulted in lower strength platforms. For example, many of the early platform designs used the 25 year "Glenn" wave, which is now known to be inadequate. If a platform is known to be designed according to this criteria, then the platform may have inadequate capacity.

Table 7-2
Example Force-Capacity Algorithms

a. Forces acting on platform (Wen, 1988)

$$OTM = C_1 (H + C_2 V)^{C_3} + C_4 W^2$$

where

OTM	=	Platform overturning moment
H	=	Wave height
V	=	Current velocity
W	=	Wind velocity
C_1	=	Scaling factor for a given platform
C_2	=	Importance of current versus wave height
C_3	=	Importance of drag versus inertia load
C_4	=	Wind factor

b. Relative platform capacity measured by RSR (Aggarwal, 1991)

$$RSR = \frac{[R_1 x R_2 x R_3 x R_4 x R_5]}{[S_1 x S_2 x S_3]}$$

where

RSR	=	Reserve strength ratio
R_1	=	Material factor
R_2	=	Platform condition factor
R_3	=	Platform modifications factor
R_4	=	Structural configuration factor
R_5	=	As-installed stage factor
S_1	=	Design criteria variation factor
S_2	=	Deck elevation factor
S_3	=	Platform modifications factor

Section 8
Future Interfaces

8.1 OBJECTIVES

One of the key features of the central database is the ability to exchange information between different computer codes via a central location. For example, CAIRS can import damaged member information to the database, which can then be transmitted to CAP as input to structural integrity analysis or perhaps transmitted to another computer program to assist in planning future inspections.

The plan for OPES is to provide as flexible system as possible that can interact with a variety of computer codes. The primary interfaces deemed as necessary for platform assessment are the inspection interface (e.g. CAIRS) and the structural analysis interface (e.g. CAP). These interfaces will be developed during the initial portions of the project.

Other interfaces that improve the capability of the system can also be linked to OPES. These interfaces either add or improve existing capabilities. Examples are reliability evaluations, inspection planning and interface with a similar system for topsides. The remainder of this section discusses several examples of these types of interfaces. Note that other interfaces are also possible with this being just a selected few of the more promising possibilities.

8.2 PLATFORM RELIABILITY

8.2.1 Determining Platform Reliability

The determination of platform reliability is a difficult issue that has received considerable attention (PMB 1987-1990, Bea, et al., 1988). Several first-order procedures (mean strength plus standard deviation) have been proposed and implemented in previous studies (Bea, et al, 1988). These types of procedures are useful for performing parametric studies and for bounding problems, however, more exact techniques are required to truly define platform reliability.

Based upon this background, there has been a recent trend to implement more exact reliability techniques using advanced first- and second-order reliability methods (FORM/SORM). These applications are in the form of software packages such as RELACS (Risk Engineering, Inc.) and PROBAN (Veritas Sesam Systems), other programs may exist as well. Future interface with these types of programs will provide the capability for improved platform reliability evaluations. OPES would serve as a source of platform data for the programs as well as a link to other programs such as CAP. Thus via the central database, structural analysis and reliability programs would in fact be "compatible" with the ability to exchange information. This type of interface provides a powerful tool for reliability evaluations.

8.2.3 Determining Platform Acceptability

Another potential reliability related interface is a platform acceptability program. This program would account for issues such as probability of failure and consequences of failure (e.g. potential injuries, lives lost, pollution, etc.) to assist in determining acceptability of a platform. Figure 8-1 shows an example of this type of relationship, taken from the AIM studies (PMB, 1988). The program could also be structured to determine cost-benefit relationships that could be used to select alternative repair options for a platform. This type of program is not known to exist and would have to be developed as part of this or another project.

8.3 INSPECTION PLANNING

Inspection planning is becoming more important, particularly since it is a current MMS requirement. Key issues are when to inspect, where to inspect and how much to inspect. Several approaches have been identified (MTD,1990; PMB, 1990) which use information such as result from last inspection, primary platform members identified by platform strength studies, environmental conditions, etc. to develop a logical and efficient inspection approaches.

Ideally, a system such as OPES can provide an interface for such a program. The central database contains most of the platform information required for inspection planning. The interface to CAIRS and CAP provides detailed information related to previous inspections and structural performance of the platform. A future interface to a reliability code will provide the framework for proper statistical accelerations. At this time there is no known inspection planning program that provides the required capabilities. Therefore, it is anticipated that this type of program would also have to be developed as a part of this or another project.

8.4 TOPSIDES DATABASE

The safety of offshore platforms is a function of both the platform structure and the topside facilities. In many cases, the topside facilities may be the greatest contributor to platform risk. An example of this is the failure of the Piper-A platform in 1988 which collapsed after an initiating event caused by topside operations (Lord Cullen, 1990).

Since the Piper incident, there has been considerable attention related to platform safety, with a large part of the emphasis on topside operations. Many North Sea platforms are currently being reevaluated using a "safety case" procedure to determine if they have acceptable safety.

It is likely that a similar central database system will be developed for topsides that operates similar to OPES. Ideally, such a topside oriented system would link to a platform structural system (e.g. OPES) to determine the overall platform safety (i.e. combined topside and structure reliability). There is no known topside program that currently has these features; however, it is obvious that a link of such a program to OPES will provide a powerful tool. Similar to the previously described future interfaces, the topsides program may be developed as a part of this or another project.

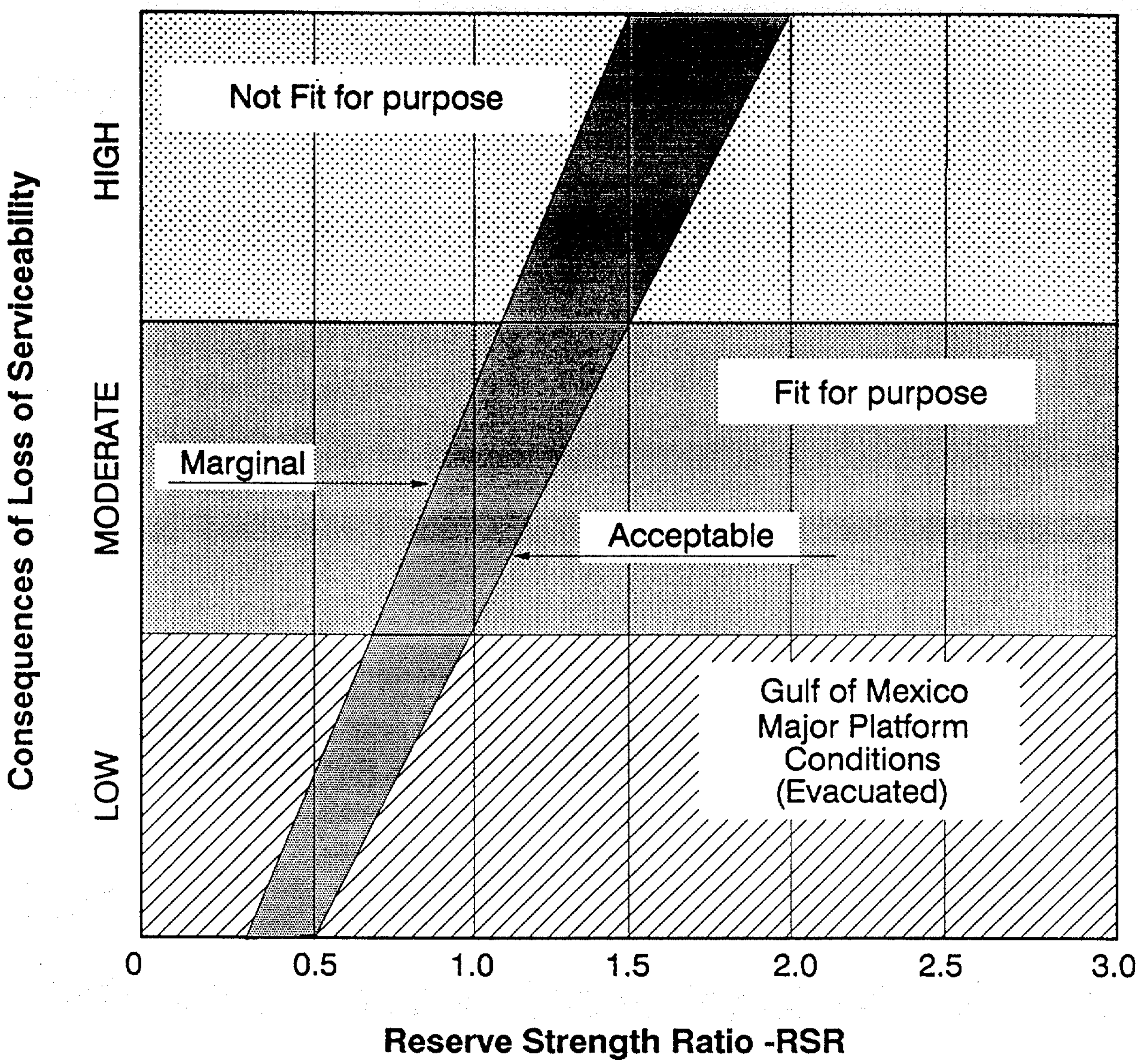


Figure 8-1 EXAMPLE PLATFORM ACCEPTABILITY RELATIONSHIP (PMB, 1990)

.031\OPES\FIG-8-1

Section 9
Software Development

This section briefly summarizes some issues associated with implementing OPES as a working computer program. More detail on these issues is provided in Appendix C. In addition, a prototype of the user interface has been developed, in the form of a ToolBook application which can run under Microsoft Windows. Refer to the "READ.ME" file on the diskette which contains the prototype for details on how to run it.

9.1 GENERAL ARCHITECTURE

The purpose of OPES is to assist the user in evaluating one or more offshore platforms. The evaluation of a platform involves gathering a variety of data from many sources, viewing and processing this data in some way, and generating reports.

To do this, the core of OPES is a central database of platform information. Information comes into this database from other databases and files, and via the user. As much as possible OPES allows the user to import data electronically from other sources such as the CAIRS inspection database, the CAP structure database, the MMS platform database, and other files that operators may have on hand. In addition, the user may directly view and enter data.

OPES also processes the data in several ways. Some of this is accomplished directly within OPES, while some is accomplished via a link to other programs.

Finally, OPES can generate a variety of reports for both internal use, and for submittal to government agencies for approval.

Figure 9-1 illustrates the general architecture of OPES. The thick line indicates the extent of OPES. Everything inside the line is part of OPES, while items outside the line are not. The thin lines indicate general communication among the pieces.

The user sits at a computer terminal and interacts with OPES via display utilities. Via the display the user can:

- Import and export data to or from external databases and files
- Perform certain types of analyses via links to external programs
- View and edit data in the central database
- Perform certain types of analyses directly within OPES
- Generate various reports

OPES is designed to have a variety of data input and output capabilities, and will provide links to an external database management system for complete data flexibility. The OPES architecture is designed to allow interaction of a variety of computer codes via the link to the central database. In this sense, the central database acts as a "warehouse" for information that can be distributed as necessary to the appropriate programs. In addition, the architecture illustrated in the figure is also designed to allow a large degree of computer and operating system independence, and promotes portability of OPES to a variety of computer systems.

9.2 INTERFACE WITH OTHER SOFTWARE

OPES will be able to import and export information from and to other software where possible. Several programs already exist which perform some of the data processing required for the evaluation of a platform and it is prudent to use these programs rather than re-build them or duplicate their capabilities in OPES.

OPES will be designed to have specific links to two programs: CAP and CAIRS. In addition, OPES will be designed to work with similar programs by including a "generic" facility to import and export specific fixed-format ASCII files containing the appropriate data. This generic link will allow the OPES user to import data from in-house or third-party inspection databases and structural analysis program, and even from well-known programs such as Lotus 1-2-3 and dBase.

9.3 USER INTERFACE

OPES will include a modern user interface that is easy to learn, easy to use, and easy to pick up if someone has not used the program for some time. In addition, the user interface will present information in ways that are easy for a human to understand and assimilate (e.g. graphical views of platform locations and geometry, query-by-example for selecting subsets of data, etc). OPES will allow the user to view data in several unit systems, provide on-line context-sensitive help, notify the user of the status of its operation, and allow use of either a keyboard or a mouse for as many operations as possible.

A better feel for the user interface can be obtained by reviewing the prototype on the diskette included with Appendix C.

9.4 TARGET COMPUTER SYSTEM

At this stage of the project it is not necessary nor desirable to specify the computer hardware required to run OPES. This should only be specified after the detailed requirements are finalized and the users have indicated their preferences. However, given the basic requirements described in this document and the general state of computer usage at various potential user's company, it is possible to state what the likely hardware will be.

It is apparent that OPES must store a lot of data, provide fast access to this data, include a modern user interface, and allow communication with other programs. In addition, it is generally more economical to use existing tools where possible to build the various pieces of a program like OPES.

These issues imply that the likely hardware will be an IBM-compatible 386- or 486-based computer with extra memory (probably 4 MB), a large hard disk (probably at least 130 MB), a high-resolution graphics display, keyboard, mouse, and network interface. The underlying operating system is likely to be DOS with Microsoft Windows providing the interface for the user. A commercially-available Data Base Management System (DBMS) that can link to other databases on a network will provide the database functions. Likely candidates are Oracle, LAN Manager, Paradox, and others.

Other possibilities for the hardware system include Unix workstations running an X Windows-based interface such as Motif or Open Look, Macintosh computers, or a proprietary system. However, these systems are not nearly as widely available within a company as are IBM-compatible computers.

9.5 DOCUMENTATION

The following documentation will be provided with OPES:

- A *User's Manual* which describes how to operate OPES, has examples of how to do various tasks, and which contains sample output available from the program.

- An *Installation Manual* which describes how to install OPES and get it to communicate with other software.

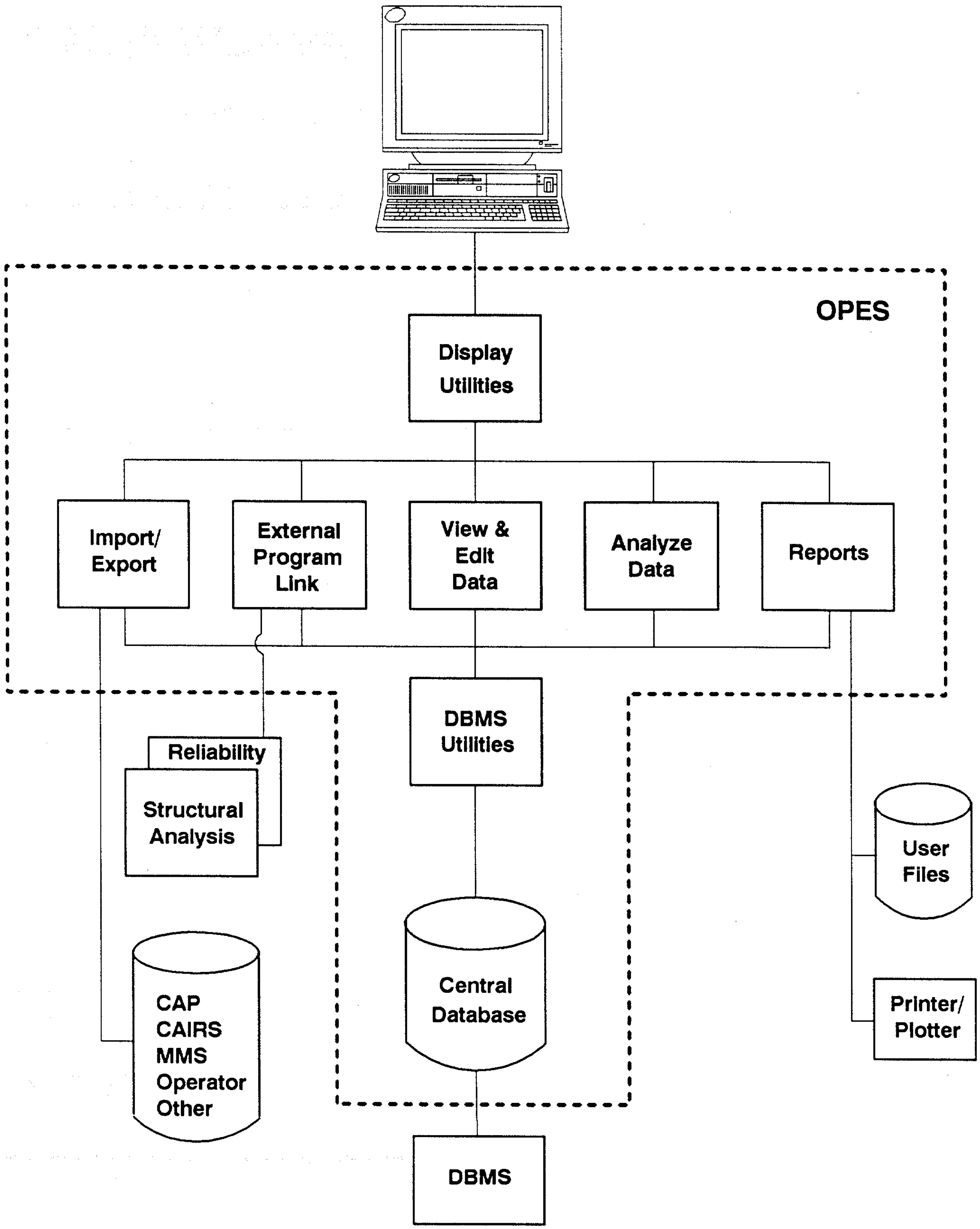


Figure 9-1 OPES GENERAL ARCHITECTURE

.031\OPES\FIG-9-1

Section 10
Conclusions and Recommendations

This study has developed a preliminary outline of a system for evaluating the structural integrity of existing offshore platforms. This report documents the study and has focused on several technical areas with discussions leading to conclusions and recommendations located throughout the report. This section summarizes several of the key conclusions and recommendations.

10.1 CONCLUSIONS

The key conclusions of the project are as follows:

1. **A Central Database is Required**

   The system was originally planned to operate with CAIRS as the database and CAP as the analysis program with the programs exchanging data directly. Upon further review, it was determined that the best approach is to instead have CAP and CAIRS interact via a central database where data is stored in a specified format and then exchanged between the programs. This is the preferred alternative because it provides the greatest amount of flexibility and does not limit use of the system to CAP and CAIRS owners. The central database approach allows for communication between a variety of programs beyond CAP and CAIRS, such as a reliability program, that can also assist in the evaluation process. A program need only be compatible with the central database to be compatible with other OPES compatible programs.

2. **A Screening Program is Required**

Given the large number of existing platforms that are a concern to both the MMS and many operators (see Table 1-1), a method is necessary for rapidly "screening" platforms to identify candidates requiring first attention for detailed analyses and/or inspection. Such a "screening" process is not known to exist in a computerized format at this time. The procedures and computer code will have to be developed as a portion of the OPES project.

3. **OPES Should be Designed to Operate Independently if Required**

Although OPES is most useful when combined with such programs as external structural analysis, inspection planning, reliability, etc., it has been structured so that preliminary platform evaluations can be performed without the need to interface with any assistance. In this case, the operator can use the information contained in the central database, along with the screening program developed for OPES to perform platform further evaluations. The process will be useful to prioritize any inspections and evaluations. Platforms identified by OPES as having potential problems can then be further evaluated off-line using external procedures or programs. Some operators may also use OPES strictly for the capabilities contained within the central database (i.e. archiving data and data queries).

4. **CAP and CAIRS Require Only Minor Revisions to be Compatible with OPES**

The current plan is to have CAP and CAIRS fully compatible with OPES. These programs were selected for two reasons. First, development of a computer code such as OPES requires "base case" programs to serve as a format for developing several of the interfaces and processes. CAP and CAIRS both meet the specific analysis and inspection capabilities required for platform evaluations, and therefore were selected as the base case programs. Second, CAP and CAIRS are used by the MMS as well as several operators. Review of these two programs during this project indicates that CAP and CAIRS will require only minor revisions to meet the specific needs of OPES.

5. **Other Computer Programs Should be Able to Interface with OPES**

It is recognized that not all operators have access to CAP and/or CAIRS. These operators may use internally developed programs or own rights of use to other structural analysis or inspection programs. In order to meet the needs of these operators, OPES will be designed with built-in "generic" interfaces for the various portions of the program that can be used to link to just about any type of external program. The only requirement is that the external program provide the data in the specific OPES generic format.

10.2 RECOMMENDATIONS

The key recommendations of the project are as follows:

1. **Continue with OPES Development Using This Document As the Preliminary Design of the System**

This document has described the proposed format for OPES with the focus on the general operation and capabilities of the system rather than specific details. The system requires further design in the next phases of the project with this document being the recommended basis of further development.

2. **Increase the Level of Process Development in Phase II**

The original plan for OPES was to develop a preliminary specification in Phase I, followed by a detailed specification in Phase II, with coding in Phase III. However, as noted above, this study has concluded that a screening process is required to adequately and cost effectively address the evaluation of the over 3,800 platforms locate in US OCS waters. This screening process needs to be developed and refined with a majority of the process development work to be performed during Phase II prior to program development in Phase III. In addition, Section 5 has described how the platform inspection and documentation process needs to be further investigated to ensure inspection results (i.e., damage) are being described in a logical and consistent manner that is useful for structural analysis purposes. Depending upon participant requirements, direct interface with programs other than CAIRS and CAP may be required. These efforts will increase the scope of Phase II by about 30 percent.

3. **Joint Industry Participation is Essential**

The technical input, experience base and regulator-industry discussions typical of joint industry projects will significantly enhance the capability and performance of OPES. This is particularly true for issues such as the particular contents of the central database and development of an acceptable rule-based platform screening process. It is recommended that joint industry participation be pursued for continuation of the OPES project.

Section 11
References

Aggarwal, R. K., "Methodology for Assessment by Regulatory Bodies of The Safety of Existing Steel Offshore Platforms," D.Eng. Dissertation, Department of Civil Engineering, University of California, Berkeley, December 1991.

American Petroleum Institute, "Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms," API Recommended Practice 2A (RP 2A), Nineteenth Edition, August 1991.

Bea, R. G., Puskar, F. J., Smith, C. E. and Spencer, J. S., "Development of AIM (Assessment, Inspection, Maintenance) Programs for Fixed and Mobile Platforms, OTC Paper 5703, Offshore Technology Conference, Houston, Texas, May 1988.

Cooper, C. K., "Parametric Models of Hurricane-Generated Winds, Waves and Currents in Deep Water," OTC Paper 5738, Offshore Technology Conference, Houston, Texas, May 1988.

Lord Cullen, "The Public Inquiry into the Piper Alpha Disaster," Department of Energy, London, U.K., November 1990.

Engineering Dynamics Inc., "SACS Computer Program," Kenner Louisiana.

Exxon Production Research Company, Platform Exposure Database (PED), Letter to Industry, December 5, 1990.

The Marine Technology Directorate (MTD), "Underwater Inspection of Steel Offshore Installations: Implementation of a New Approach," Report to Industry, MTD Publication 89/104, 1989.

Massachusetts Institute of Technology, STRUDL (Structural Design Language) Computer Program, Cambridge, Massachusetts.

McGannon, R. L., "Risk and Reliability Management in U.S. Offshore Oil and Gas Operations," Reliability of Offshore Operations: Proceedings of an International Workshop, NIST Special Publication 833, April 1992.

Minerals Management Service, Memo to PMB Engineering Inc., April 16, 1992.

Minerals Management Service, "International Conference on Reliability of Offshore Operations," National Institute of Standards and Technology, Gaithersburg, Maryland, March 20-22, 1991.

Moan, T. and Taby, T., "Collapse and Residual Strength of Damaged Tubular Members," Proceedings of the Conference on Behavior of Offshore Structures, BOSS ;85, Delft, July 1-5, 1985.

PMB Engineering, Inc., "AIM – Assessment, Inspection, Maintenance, Phase IV," Joint Industry Study, May 1990.

PMB Engineering, Inc., "AIM – Assessment, Inspection, Maintenance, Phase III," Joint Industry Study, September 1988.

PMB Engineering, Inc., "AIM – Assessment, Inspection, Maintenance, Phase II," Joint Industry Study, October, 1987.

PMB Engineering, Inc., "Assessment, Inspection and Maintenance (AIM) of Offshore Platforms, Phase 1," Prepared for the MMS, June 1987.

PMB Engineering, Inc., "Brace Buster" Computer Program, San Francisco, CA, 1991.

PMB Engineering, Inc., "CAP – Capacity Analysis Computer Program," San Francisco, CA.

PMB Engineering, Inc., "Development of Platform AIM (Assessment, Inspection, Maintenance) Programs, Phase II," Joint Industry Study, October 1987.

PMB Engineering, Inc., "Further Investigation into Capacity Analysis Procedures," Proposal for Joint Industry Project, April, 1992.

Risk Engineering, Inc., "RELACS," Computer Program, Golden, Colorado.

Solus Schall, "CAIRS – Computer-Aided Inspection and Reporting System Computer Program," Houston, Texas.

Veritas Sesam Systems, Inc., "PROBAN," Computer Program, Houston, Texas.

Wen, Y. K., "Environmental Event Combination Criteria Phase 1, Risk Analysis," Research Report for API PRAC 87-20, July 1988.

APPENDIX A
OFFSHORE PLATFORM EVALUATION SYSTEM
CENTRAL DATABASE

PLATFORM FLEET DATABASE

100 Background Data

105	MMS complex ID number
110	Platform number
115	Platform name
120	Location (block or area)
125	Operator
130	Platform type (production, drilling, quarters, etc)
135	Year installed
140	Original design life
150	Type of production (oil, gas)
155	General configuration (4-pile, 8-pile)
160	Number of wells
165	Manned/unmanned

200 Structural Data

205	Number of legs
210	Number of horizontal elevations
215	Joint cans (yes/no)
210	Number of piles
215	Min/max pile penetration
220	Legs/piles grouted (yes/no)
225	Number of existing conductors
230	Deck elevation

300 Site Data

305	Water depth
310	Distance form shore
315	Design wave height
320	Reference wave height (e.g. API reference height)
325	General soil type (soft clays, silts, etc)
330	Seismic zone (1, 2, 3, 4)

400 Inspection Data

405 Last date of inspection
410 Type of last inspection (API Level 1, etc.)
415 Existing unrepaired dents/holes
420 Existing unrepaired bent members
425 Existing unrepaired cracks
430 Existing unrepaired flooded members
435 Existing corroded members
440 Existing other damage
445 Number of CP readings below limit
450 Percent of anode depletion

500 Strength Data

505 Last date of strength evaluation
515 Platform capacity
510 Number of overstressed members
520 Platform reserve strength ratio
525 Distance deck is above or below design wave
530 Probability of platform failure
535 Number of members with fatigue life below allowable

SINGLE PLATFORM DATABASE

1000 General Platform Data

- 1100 Platform Description
- 1200 Age Data
- 1300 Upgrades and revisions

2000 Structural Data

- 2100 Jacket Data
- 2200 Deck Data

3000 Site Data

- 3100 Location Data
- 3200 Meteorologic-Oceanographic Data
- 3300 Geotechnical Data
- 3400 Seismic Data
- 3500 Other Data
- 3600 Original Criteria

4000 Inspection Data

- 4100 Inspection Chronology
- 4200 Summary Results
- 4300 Detail Results (CAIRS)
- 4400 Inspection Plans

5000 Strength Data

- 5100 Assessment Chronology
- 5200 Summary Results
- 5300 Detail Results (CAP)

1000 GENERAL PLATFORM DATA

1100 Platform Description

1105 Platform ID - e.g. Ship Shoal 199-A
1110 Owner
1115 Block or Area (e.g. Eugene Island)
1120 Original designer
1125 CVA
1130 Platform Type (Production, Drilling and Production, Quarters, Transfer Station, Storage, Other)
1135 Structure Type (Conventional Fixed Base, Caisson, Tripod, Cook Inlet, TLP, FPS, other)
1140 Manned/unmanned (identify number of personnel)
1145 Number of Wells
1150 Evacuation Methods (boat, helicopter)
1155 Helideck Size (or none)
1160 Type of production - oil/gas
1165 Production Rate - bbl/day

1200 Age Data

1205 Date Installed
1210 Original design life
1215 Current estimate of remaining field life
1220 Number of wells
1225 Original Design Basis (RP2A Edition, Lloyds, other certification basis)

1300 Upgrades or Revisions

1305 Upgrade Chronology
1310 Date
1315 Descriptive Short Name (e.g. Strengthened piperack)
1320 Detailed Description (memo)

2000 STRUCTURAL DATA

2100 Jacket Data

2105 Jacket

2105.05 3-dimension coordinates of all nodes
2105.10 Tubular member sizes (20" dia 5/8" wall thick, etc.)
2105.15 Unusual jacket members, if any (AISC W or T Shapes, etc.)
2105.20 Joint cans - length and wall thickness
2105.25 Material type - A36, A537, etc. Mil cert data if available.
2105.30 Intentionally flooded members
2105.35 Weld details (i.e. profiled, ground)

2110 Foundation System (Piles assumed)

2110.05 General Type - leg, skirt
2110.10 Number of piles
2110.15 Location of each pile - Leg A1, Leg B1, Leg C1 - 3 skirt piles, etc.
2110.20 Diameter, wall thickness and schedule - by pile
2110.25 Material type - A36, A537, etc. Mil certs if available
2110.30 Original pile design penetration
2110.35 Actual Penetration depths - by pile, per driving records or estimated
2110.40 Pile connection - welded/grouted

2120 Conductors

2120.05 Number
2120.10 Sizes (26" dia, 3/4" wall thick, etc.)
2120.15 Material type - A36, A537, etc. Mil cert data if available.

2130 Appurtenances (item, location and size)

2130.05 Walkways, barge bumpers, boat landings, stairways, etc
2130.10 J-tubes and risers

2140 Corrosion Protection

2140.05 Type - anode/impressed current
2140.10 Number and location of anodes
2140.15 Coatings or sheathing (monel)

2000 STRUCTURAL DATA (Continued)

2150 Damage

2150.05 Dents

2150.0505 Location - distance from leg, circular location (degrees or time coordinate)
2150.0510 Size - diameter, length, depth

2150.10 Cracks
2150.1005 Type - partial or thru crack
2150.1010 Location - circular location (degrees or time coordinate)
2150.1015 size - length

2150.15 Holes
2150.1505 location (similar to dent)
2150.1510 size - diameter and length

2150.20 Flooded Members
2150.2005 Members Checked
2150.2010 Members Flooded

2150.25 Corroded Members
2150.2505 Members checked
2150.2510 Members with severe corrosion (less than same threshold levels, e.g., 60 percent or original thickness remains)

2150.30 Other damage

2000 STRUCTURAL DATA (Continued)

2215 Equipment Information

2215.05 Deck dead and live loads from original design. Also need relative geometry of all equipment to compute wind loads.
2215.10 Actual deck loads based upon deck survey. All structures and equipment including buildings, drill rigs, pipe racks, mud tanks, etc.
2220.15 Special concerns such as hook loads and localized loads from cranes, flarebooms, bridge to adjacent structure, etc.

2220 Structural Appurtenances (item, location and size)

2220.05 Drill rigs
2220.10 Flare Booms
2220.15 Bridges
2220.20 Other

2225 Damage (Structural)

2225.05 Dents
2250.0505 Location - distance from leg, circular location (degrees or time coordinate)
2250.0510 Size - diameter, length, depth

2225.10 Cracks
2250.1005 Type - partial or thru crack
2250.1010 Location - circular location (degrees or time coordinate)
2250.1015 size - length

2225.15 Holes
2250.1505 location (similar to dent)
2250.1510 size - diameter and length

2225.20 Corrosion - material loss on members
2225.25 Other damage

3000 SITE DATA

3100 Location Data

3105 General Region - Gulf of Mexico, California, Alaska, etc. based upon some type of MMS classification. Signifies the general type of concern for platform - e.g. GOM - hurricanes.
3110 Lease/Tract number - Ship Shoal 199
3115 Coordinates
3120 Orientation
3125 Miles from shore

3200 Meteorologic - Oceanographic Data

3205 Water Depth for design - MLW plus tide plus surge
3210 Design wave height and period
3215 Design current
3220 Random seas, etc. that may be needed for compliant-type structures
3225 Primary hydrodynamic loading directions
3230 Marine growth (as function of depth)
3235 General wave environment (e.g. Wave height/current versus return period for the site)
3240 Other criteria (Operating conditions, Fatigue)
3245 Design Wind Speeds
3250 Air Temperature Extremes (for Arctic applications)

3300 Geotechnical Data

3305 General type (soft clays, stiff clays, silts, sands, etc.)
3310 Soil profile - soil layers and engineering properties
3315 Strength profile (strength versus depth, if available)
3320 Pile-soil strength curves (p-y and t-z, if available)
3325 Other special soil issues (e.g. - mudslide zone)

3400 Seismic Data

3405 Strength level data - strength level spectra
3410 Ductility level data:
3410.05 Ductility level spectra
3410.10 Ductility level time history (e.g. scaled Loma Prieta)

3415 General seismic environment (e.g. peak ground acceleration versus return period)
3420 Deck spectra

3000 SITE DATA (Continued)

3500 Other Data

3505 Ice - ice strength, ice thickness, ice loading scenarios (sheet ice, rafted ice, ice impacts), etc.

3600 Original Criteria - Original environmental design criteria, if available (e.g. wave heights, Cd, Cm, soils, etc.)

4000 INSPECTION DATA

4100 Inspection Chronology

- 4105 Date
- 4110 Descriptive Short Name (e.g. yearly inspection, inspection following large hurricane, etc.)
- 4115 Performed By (Oceaneering, etc.)
- 4120 Further Written Detail (memo)

4200 Summary Results

- 4205 Jacket Damage
  - 4205.05 Dents
    - 4205.0505 Location - distance from leg, circular location (degrees or time coordinate)
    - 4205.0510 Size - diameter (width), length, depth
  - 4205.10 Cracks
    - 4205.1005 Type - partial or thru crack
    - 4205.1010 Location - circular location (degrees or time coordinate)
    - 4205.1015 size - length
  - 4205.15 Holes
    - 4205.1505 location (similar to dent)
    - 4205.1510 size - diameter and length
  - 4205.20 Flooded Members
    - 4205.2005 Members Checked
    - 4205.2010 Members Flooded
  - 4205.25 Corroded Members
    - 4204.2505 Members checked
    - 4205.2510 Members with severe corrosion (less than same threshold levels, e.g., 60 percent or original thickness remains)
  - 4205.30 Other damage
- 4210 Deck Damage
  - 4210.05 Dents
    - 4210.0505 Location - distance from leg, circular location (degrees or time coordinate)
    - 4210.0510 Size - diameter, length, depth

4210.10 Cracks

4210.1005 Type - partial or thru crack

4210.1010 Location - circular location (degrees or time coordinate)

4210.1015 size - length

4000 INSPECTION DATA (Continued)

4210.15 Holes

4210.1505 location (similar to dent)

4210.1510 size - diameter and length

4210.20 Corrosion - material loss on members

4210.25 Other damage

4220 Other Findings

4215.05 Measured Marine Growth Profile

4215.10 Cathodic Protection (average CP readings and any CP readings below limit, percent depletion of anodes)

4215.15 Bottom Survey (summary of debris and scour)

4215.20 Risers (riser or clamp damage

4215.25 Photos/Videos Available (summary list of what's available via interface with CAIRS)

4300 Detail Results - Interface with CAIRS or Other Inspection Database Program

4400 Inspection Plans

4100 Next Scheduled Inspection

4200 Descriptive name for inspection (e.g. per MMS requirements)

4300 Further Written Detail

5000 STRENGTH DATA

5100 Assessment Chronology

5105 Date
5110 Descriptive Short Name (e.g. Static pushover, Dynamic pushover, quick check following boat impact damage, etc.)
5115 Performed By (Operator, PMB, etc.)
5120 Further Written Detail (memo)

5200 Summary Results

5205 Type of evaluation - unity check, capacity check, both.

5210 Unity check

5210.05 Number of members overstressed per design criteria
5210.10 Detail of overstressed members plus their unity check

5215 Capacity check

5215.05 Platform capacity (kips, etc.)
5215.10 Load-deformation curve (global shear vs deck deflection)
5215.15 Return period of wave causing platform failure
5215.20 Distance wave is above or below deck at failure
5215.25 Reserve Strength Ratio
5215.30 Probability of platform failure

5210 Fatigue check
5220.05 Lowest fatigue life for any member
5220.10 Number of members with fatigue life below allowable

5300 Detail Results - Interface with CAP or Other Structural Analysis Program

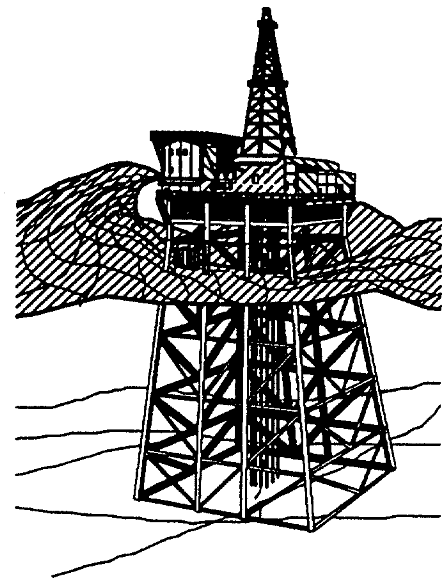
APPENDIX B

CAP AND CAIRS DESCRIPTIONS

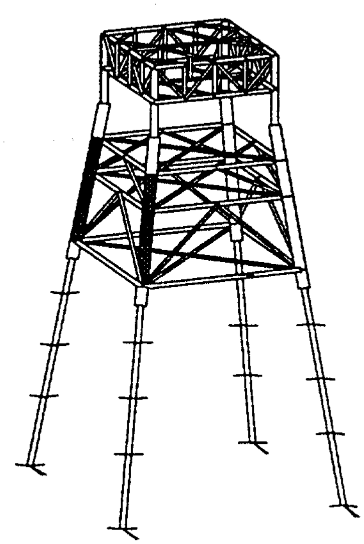
PMB Software

CAP *Capacity Analysis Program*

CAP (Capacity Analysis Program) is an integrated environment for performing collapse and overload analyses of fixed offshore platforms. CAP combines graphical model generation, analysis, and graphics post-processing capabilities in one system.



CAP displays models graphically on screen, and the user can rotate, pan, and zoom the model; edit the nodes, members, and loads; change between 2D and 3D views; and perform a variety of other model editing tasks on screen using the mouse, pull-down menus, and pop-up data entry boxes.

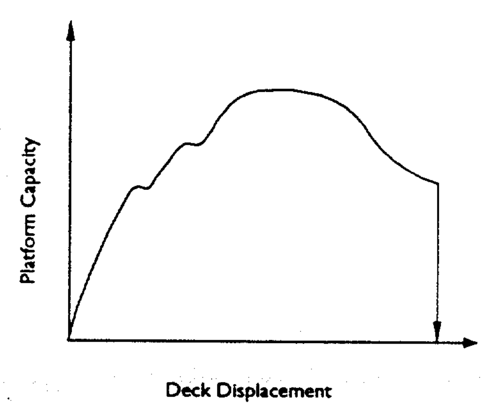


CAP has built-in model generation features which allow the user to quickly develop a structural model of an offshore platform or deepwater tower.

SEASTAR is the underlying analysis module of CAP, giving CAP the capabilities of that program. During analysis, CAP displays up-to-date progress information.

CAP can read SEASTAR, SACS, and STRUDL input files, providing the ability to import models developed for those systems.

CAP has built-in graphical features which allow the user to display many results on screen. These include deformed shapes, applied loads, nodal displacements, element forces, and other items as a function of time or deck displacement, member interaction ratios (different ranges in different colors) at various points in the analysis, inelastic events, etc.



Elements:
CAP has a wide range of elements in its library, including:

- o Linear beam
- o Nonlinear truss
- o Large displacement beam
- o Inelastic beam
- o Support (contact)
- o Linear quadrilateral plate
- o Wave load
- o Marshall Strut Cable
- o Buckling Beam with automatic generation of damaged member properties (dents and holes)
- o Shim (for ungrouted piles)
- o Nonlinear soil element which can accept nonlinear P-Y and T-Z curves as input, or generate them based on API recommendations, and includes one-way cyclic degradation, hysteretic behavior during cyclic loading, radiation damping, gapping, and strain-rate effects.

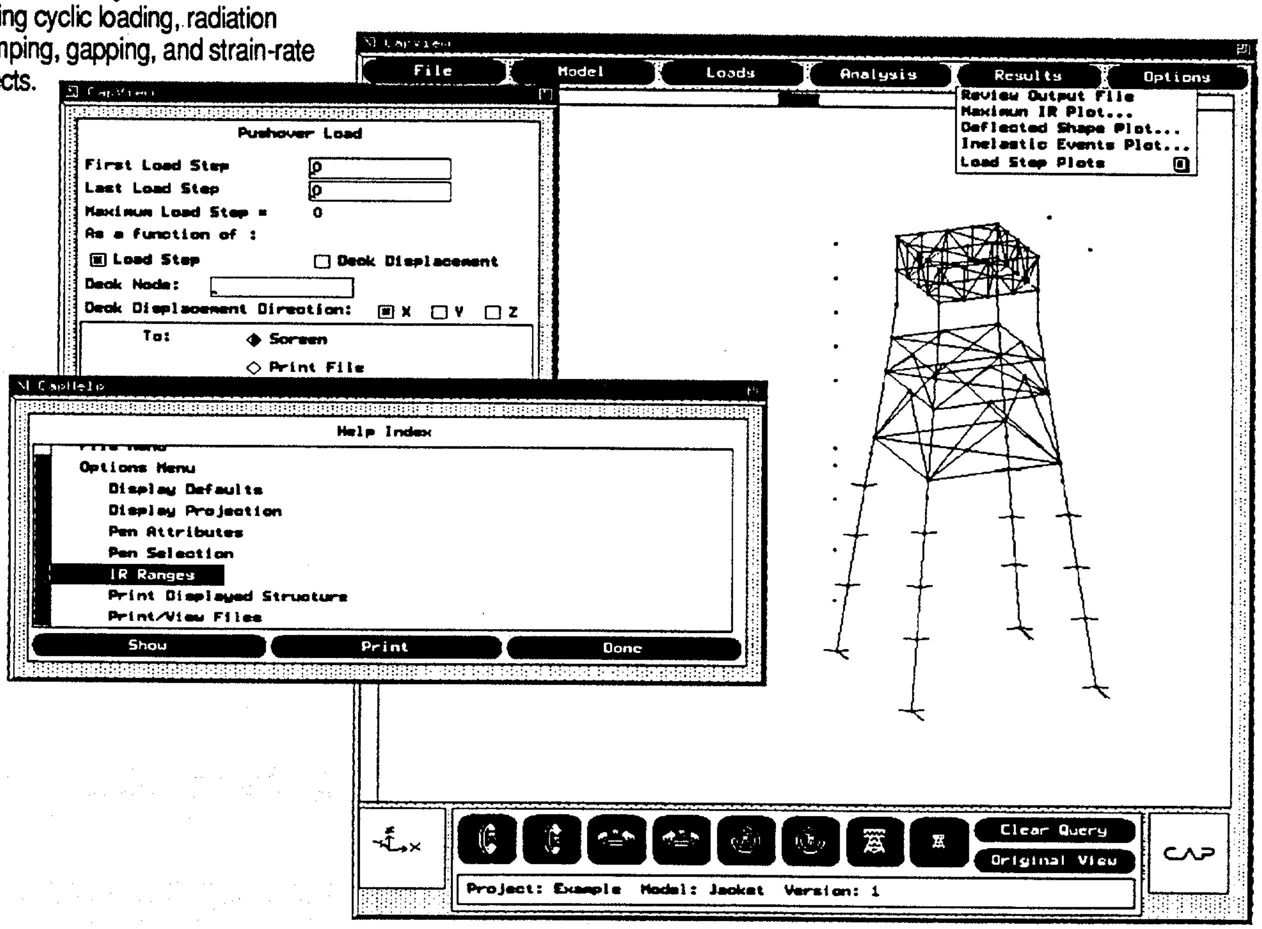
Loadings:

- o Nodal force/displacement loading
- o Gravity, buoyancy, inertial, and hydrodynamic loads, including variable buoyancy and inertia, hydrodynamic drag and inertia with wave/current interaction, and tangential drag forces. Water kinematics may be generated from a variety of internal mathematical models or from user specification.

Analysis Capabilities:

- o Static solution strategies for stiffening, softening, instability, and material and geometric nonlinearity problems.
- o Eigenvalues and eigenvectors
- o Frequency analysis capability captures the effect of geometry and loading on initial stiffness.
- o Variable time-step nonlinear time-domain dynamic analysis of any structure subjected to time-varying loading, including earthquake excitations.

System Requirements:
CAP runs on Sun SPARCStations running UNIX, and uses X windows for graphics. CAP supports HPGL and Postscript for hardcopy output.



PMB Software

500 Sansome St., San Francisco, CA 94111 ■ (415) 986-4166

PLATFORM CAIRS

OVERVIEW

The Platform CAIRS system has been used on hundreds of structures over the last 5 years. There are numerous versions of this system, reflecting the requirements of individual clients and their respective certification standards. This is, therefore, a generic description describing the facilities available to prospective clients.

DESCRIPTION and BENEFITS

For each item of inspection data, the CAIRS package stores a location code based on the items position on the structure in relation to legs, depths and distances from nodes. A structural component code can also be entered. The following inspection categories are included in this particular configuration:

- Cathodic Protection Survey - Records CP readings in negative millivolts taken both inside and outside the structure. In the report production basic statistics (high, low, mean, variance and standard deviation) are calculated and displayed.

- Special Cathodic Protection - Used only when readings in the CP survey fall below a pre-specified value. The information is geared towards providing information required when fitting replacement sacrificial anodes.

- Anode Survey - For each anode inspected, the system records dimensions, attachment details, marine growth cover and CP readings. The volume of the anode is calculated, and provided the original volume is known the percentage depletion is calculated.

- Marine Growth - Stores inspection data on the type, thickness and estimated percentage cover at various points on the structure.

- Debris - The type, description and dimensions of any item of debris on or around the structure are recorded. The system prompts for a flag to indicate any damage caused and whether or not the debris was removed during the inspection. Damage caused should be recorded in the damage survey category.

- Bottom Survey - Records pneumofathometer readings at locations on the base of the structure, the bottom type, and the presence and measurement of any scour, deposition or mudmats.

- Riser - For each riser inspected, the size, type, tube turn and distance the pipeline is suspended are recorded. Various indicators are also prompted for to indicate damage, coating damage, presence of guard etc. For each clamp inspected on the riser various items of data are stored to record the condition of each clamp.

- Topside Rigging - Includes information on the overall integrity of the topside of the structure. Much of the information is helpful in planning remedial or repair work. The system stores data on the pipe diameters, web widths on I beams, deck space, risers, boat landings, and the availability of cranes and living quarters.

- Selected Node - Records the data collected during a detailed inspection of selected structural node welds. For any defects on the weld the position, type, pitting, weld definition and dimensions are stored. If a crack is detected this is cross referenced to an MPI report and measurement of wall thickness on the leg and member and CP readings are recorded.

- MPI - Where an MPI survey has been carried out (e.g. cracks on members, welds, etc) the system records various items of data on how the inspection was performed, what techniques and equipment were used and the technician's name and qualifications.

- Damage Cracks - This option should be used to record all cracks found during the inspection. The system records the dimensions of the crack and specifies whether holes have been drilled and MPI performed. To assist the repair specification the database also stores information on the orientation and position of the crack in relation to its surroundings.

- Damage Holes/Dents - Stores data on holes and dents discovered during the inspection. The system calculates the ratio of the hole or dent to the original diameter of the member.
- Detailed Damage - Recorded for any hole or dent which requires to be repaired. Damage type, orientation, dimensions, member and leg diameters and wall thickness are recorded. Additional data may include cause of damage, taut wire measurements and description of possible obstacles to the repair.
- Repair Status - Records data of inspection of previous repairs. Includes presence of any cracks and doubler plate condition.
- UT Flaw Detection - Includes data on technician, equipment used, material inspected, procedures, calibration and acceptance standards.
- Wall Thickness - Cross referenced to UT report, including data on original thickness, orientation of readings and readings themselves.
- Photo Log - Lists all photographs taken during inspection. In the final report captions are printed for the corresponding categories in the report.
- Video Log - Stores a description of footage, counts for points of interest on tape.
- General Comments

In addition to the standard features of CAIRS - data entry, data modification, reporting, searching, sorting and system maintenance the system has the following special options:

- **Graphics** - Plots, on screen and hard copy, of trends in marine growth thickness versus depth, CP readings versus time and depth and wall thickness versus time.
- **Anomaly Reports** - Standard pre-defined anomaly reports as well as reports produced after searching data to isolate data considered anomalous.
- **Batch Printouts** - Up to 10 final reports can be queued and printed.
- **Location Printouts** - Print out by location order all locations which have been subject to any form of inspection during the programme.
- **Raw Data Printout** - Unformatted list of inspection data for a structure for cross checking and verification before final report production.

ADVANTAGES

The system can be used offshore and data entered as the inspection job progresses. Critical data is sent, via modem, onshore where it can be re-checked while the vessel is still in-situ and remedial action taken immediately without having to re-mobilise.

In this way the client has immediate access to his inspection reports, in a magnetic format, via the CAIRS facilities, almost immediately on completion of the inspection program.

In addition as the system will be used from one year to the next you are guaranteed a standard and consistent data reporting format and the ability to compare and analyse data from one inspection to the next. It is not essential that the same inspection contractor be used from one year to the other as they do not define what the data formats will be.

APPENDIX C

PRELIMINARY SPECIFICATION

OPES

OFFSHORE PLATFORM EVALUATION SYSTEM

APPENDIX C

PRELIMINARY SOFTWARE SPECIFICATION

BY
PMB ENGINEERING, INC.
SAN FRANCISCO, CALIFORNIA
MAY, 1992

TABLE OF CONTENTS

1. INTRODUCTION

This document presents the preliminary software specification for OPES (Offshore Platform Evaluation System). OPES is a computer program designed to assist engineers in the process of evaluating and re-qualifying existing offshore platforms.

1.1 Purpose and Scope

The purpose of this document is to specify what OPES does and how it works. This document was prepared as part of a pilot project for the Minerals Management Service (MMS). Because that project was the first of several phases required for the development of OPES, and was performed as a research project for the government prior to industry participation, this specification should be considered preliminary in nature and represents the general desires and goals for OPES rather than firm details of its capabilities and operation.

1.2 Business Objectives

Aging offshore oil and gas platforms often require special evaluation to ensure that they have adequate structural integrity. This is a difficult process involving inspection of the platform, gathering and interpreting a wide variety of data from many different sources, assessing the integrity of the platform based on this data, and in some cases preparing reports and submittals for government agencies.

The purpose of OPES is to make this process simpler and more consistent for both the owners of the platforms and for the government agencies that are involved.

1.3 Organization of Document

This introductory section briefly discusses the purpose and scope of this document, describes its organization, lists some related documentation, and includes a short summary of several special terms and abbreviations used in the document.

Section 2 gives an overview of OPES, describing its general architecture and interface with other related programs.

Sections 3, 4, and 5 form the main body of the document. Section 3 describes the information that is stored and processed by OPES. Section 4 lists the functional requirements for OPES, and provides some preliminary details of how those functions are performed. Section 5 describes how OPES interacts with the user and the outside world.

Finally, section 6 discusses other requirements for OPES, such as the computer system on which it should run, and how it should be developed.

1.4 Related Documentation

The following documents relate to the design of OPES and are referenced at various points in this specification. The number listed next to each document in square brackets serves as a reference number and is used in lieu of the complete reference in subsequent sections.

[1] "Offshore Platform Evaluation System (OPES), Phase 1, Final Report", Report to MMS, PMB Engineering Inc., May 1992.

1.5 Terms and Abbreviations

The following terms and abbreviations are used throughout this document.

CAIRS	-	Computer-Aided Inspection and Reporting System. A database program developed by Oceaneering to store platform inspection data.
CAP	-	Capacity Analysis Program. A nonlinear structural analysis program developed by PMB to perform static and dynamic pushover analyses of offshore platforms.
CASE	-	Computer-Aided Software Engineering.
DB	-	Database.
DBMS	-	Database Management System.
DFD	-	Data Flow Diagram. A computer-aided software engineering (CASE) tool to depict the operation of a program from the viewpoint of the data.
MMS	-	Minerals Management Service, a division of the United States Department of the Interior.
OPES	-	Offshore Platform Evaluation System. The system described in this document.
PMB	-	PMB Engineering, Inc.

2. SYSTEM DESCRIPTION

This section provides a high-level, non-technical description of OPES to help the reader see and understand the key conceptual issues. Later sections of this document discuss technical issues in more detail.

2.1 Overview

The purpose of OPES is to assist the user in evaluating one or more offshore platforms. The evaluation of a platform involves gathering a variety of data from many sources, viewing and processing this data in some way, and generating reports.

Figure 2.1-1 illustrates the general concept behind OPES. As the figure shows, the core of OPES is a central database of platform information. Information comes into this database from other databases and files, and via the user. As much as possible OPES allows the user to import data electronically from other sources such as the CAIRS inspection database, the CAP structure database, the MMS platform database, and other files that operators may have on hand. In addition, the user may directly view and enter data.

OPES also processes the data in several ways. Some of this is accomplished directly within OPES, while some is accomplished via a link to other programs.

Finally, OPES can generate a variety of reports for both internal use, and for submittal to government agencies for approval.

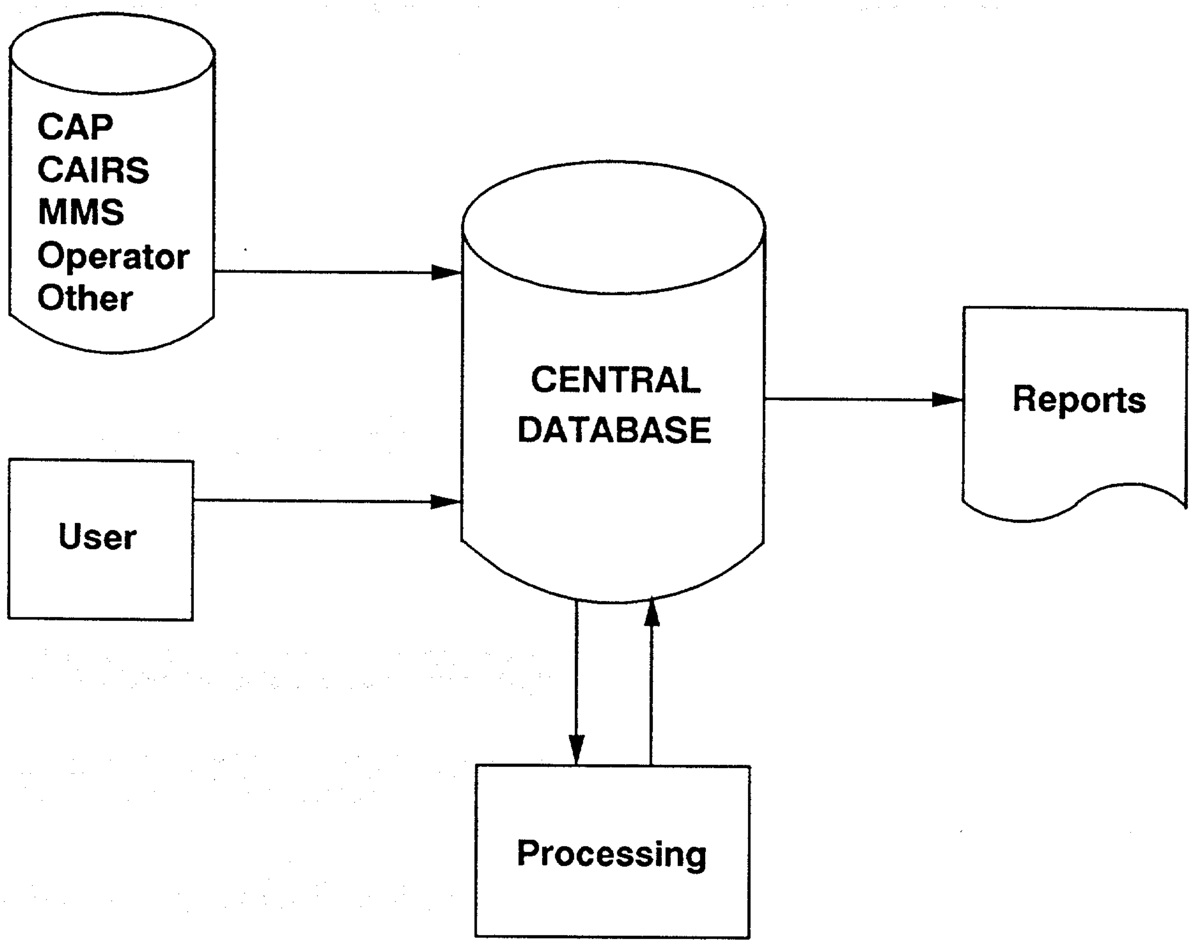


Figure 2.1-1: Conceptual Overview

.031\OMAE\FIG2-1-1

2.2 General Architecture

Figure 2.2-1 illustrates the general architecture of OPES. The thick line indicates the extent of OPES. Everything inside the line is part of OPES, while items outside the line are not. The thin lines indicate general communication among the pieces.

The user sits at a computer terminal and interacts with OPES via display utilities. Via the display the user can:

- Import and export data to or from external databases and files;
- Perform certain types of analyses via links to external programs;
- View and edit data in the central database;
- Perform certain types of analyses directly within OPES;
- Generate various reports.

In addition, although a variety of data input and output capabilities will be included in OPES, complete data flexibility will be possible via an open specification of the central database. With this specification the user can access information in OPES using an external database management system (DBMS). This gives the user a great degree of flexibility with respect to the data. Data can be entered and modified outside of OPES, and unusual reports which may not have been anticipated during the design and implementation of OPES can be prepared.

The OPES architecture is designed to allow interaction of a variety of computer codes via the link to the central database. In this sense, the central database acts as a "warehouse" for information that can be distributed as necessary to the appropriate programs. Once a program is compatible with OPES, it will be compatible with other OPES-compatible codes. this provides the greatest degree of flexibility and future expansion.

The architecture illustrated in the figure is also designed to allow a large degree of computer and operating system independence, and promotes portability of OPES to a variety of computer systems. Most of the major OPES modules are completely independent of the underlying computer system. Access to the user and the data, two operations which tend to be very system-dependent, all takes place through two modules: the display utilities and the DBMS utilities. Moving OPES to another computer system should only involve changes in these two modules, and the appropriate choice of these utilities can minimize that effort.

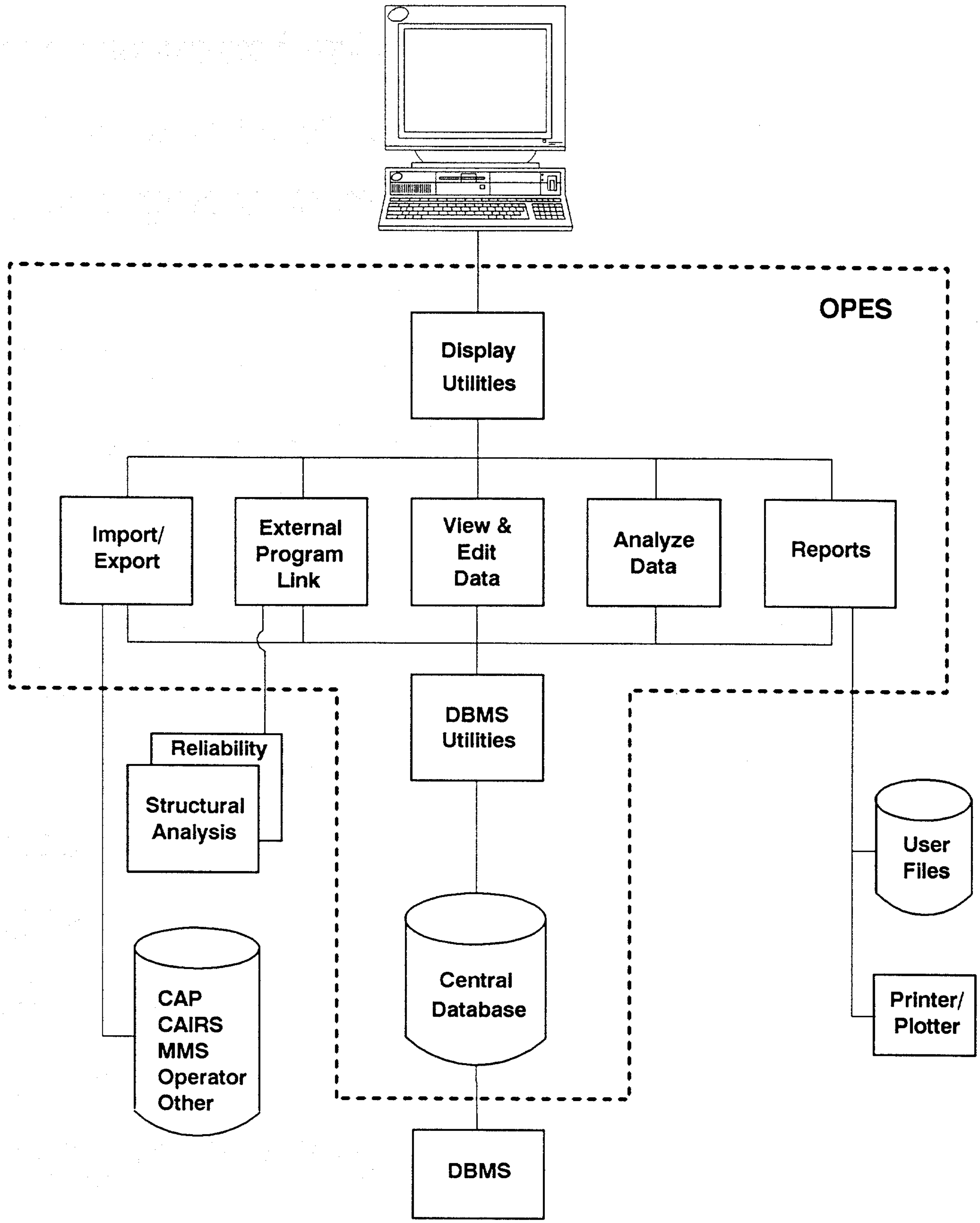


Figure 2.2-1: General Architecture

.031\OMAE\FIG2-2-1

2.3 Interface With Other Software

OPES should be able to import and export information from and to other software where possible. Several programs already exist which perform some of the data processing required for the evaluation of a platform and it is prudent use these programs rather than re-build them or duplicate their capabilities in OPES.

OPES will be designed to have specific links to two programs: CAP and CAIRS. In addition, OPES will be designed to work with similar programs by including a facility to import and export specific fixed-format ASCII files containing the appropriate data. This generic link will allow the OPES user to import data from in-house or third-party inspection databases and structural analysis program, and even from well-known programs such as Lotus 1-2-3 and dBase.

3. INFORMATION MODEL

This section presents the information model for OPES. It begins by presenting an overview of the information required to evaluate an existing platform, organized into major categories. Next, it illustrates how this information flows through and is processed by OPES. Finally, it describes the contents of each of the databases.

Note that due to the preliminary nature of this specification, the sections describing data flow and data content do not go into their respective subjects in much depth. A final specification will provide significantly more detail on these items.

3.1 Information Overview

A review of the project report [1] reveals that there are five major categories of information required for OPES. For the purposes of this preliminary specification, these categories will be handled as logical, as opposed to physical, databases. When OPES is actually implemented, each logical database may be implemented as one or more physical databases. The five databases are:

1) *General Platform Data.* The information in this category describes the name, location, operator, age, etc. of each platform in the system, and any revisions made to the platform after it was installed.

2) *Structural Data.* The information in this category describes the physical properties of the platform, including the location of all nodes, member connectivity and sizes, etc, and any damage that has occurred that affects the strength of the platform.

3) *Site Data.* The information in this category describes the meteorological, oceanographic, geotechnical, and seismic characteristics of the site where the platform is installed.

4) *Inspection Data.* The information in this category summarizes any the results of any inspections that have been performed on the platform.

5) *Strength Data.* The information in this category summarizes the results of any strength or screening analyses that have been performed on the platform.

Note that the main project report [1] also indicates that there is a platform fleet database which can be used to perform queries on groups of platforms. In reality this database is derived from the information stored in the databases described above, and is not a separate database itself, in order to avoid storing the same data in more than one place.

In addition to these categories of information, which are stored and processed as part of OPES, the program must also deal with several external sources of data. These are:

1) *MMS Data.* The MMS has a database of platform information. OPES must be able to import this data into its own databases.

2) *Corporate Information Sources.* Any company using OPES is likely to have some platform information available in electronic form. OPES must be able to import this data into its own databases. This will be accomplished through a neutral, fixed-format ASCII file.

3) *CAIRS.* A number of companies use CAIRS to store their inspection data. OPES must be able to import summaries of this data.

4) *CAP.* A number of companies use CAP to perform strength evaluations of platforms. OPES must be able to import summaries of this data.

3.2 Information Flow

This section illustrates the general sources, flow, and processing of data in OPES, in the form of data flow diagrams (DFDs). These diagrams show what information is used by each part of the program, how this information is used and flows through each of the modules, and what general processing of the data occurs. Note that DFDs do not depict control of the data and should not be interpreted like flow charts.

Figure 3.2-1 is the context diagram for OPES, and presents the data flow from the broadest perspective. Its purpose is to serve as an orientation to the system as a whole, with further diagrams providing more detail.

Figure 3.2-1 also includes a legend that applies to all the data flow diagrams. A *process* symbol, represented by a square box with rounded corners and a line across the top, depicts a data transformation (a process which converts data from one format to another). The number in the top section is an identifier, and the text in the box describes in very general terms the function performed by the box. A *data store* symbol, represented by a rectangle that has two vertical lines on the left and is open on the right, indicates a place where data is stored (a file, database, etc). Finally, a *data source / sink*, represented by one square box overlaid on top of another, indicates an entity that provides or consumes information.

The context diagram in Figure 3.2-1 indicates that OPES stores its information in a central database. Some of this information can be imported from external sources (process 1.0), the user can view and edit the data (process 2.0), and have certain analyses performed (process 3.0). In addition, OPEN can generate various reports (process 4.0) and export information for external use (process 5.0).

Figure 3.2-2 provides more detail on the import process (1.0). This figure indicates that OPES can read MMS data and corporate data files and store the information in the appropriate places in its central database. OPES can also import basic structural data from either CAP, or from a formatted ASCII file. It can also import inspection summaries from CAIRS.

Figure 3.2-3 provides more detail on the view/edit process (2.0). This figure indicates that OPES can display a map or a list of all the platforms in its databases, and allow the user to select a subset of the database by specifying constraining criteria. The user can then select one platform from the list and edit any data associated with that platform.

Figure 3.2-4 provides more detail on the analysis process (3.0). This figure shows that OPES can extract structural modifications, damage data, and soil data from its databases, send this data to a structural analysis program for processing, and retrieve and store a summary of the analysis results. Note that it is assumed that a complete structural model is provided outside of OPES so that OPES only needs to provide data on any important changes that have occurred. The figure also shows that OPES can perform a simple first-order screening analysis.

Figure 3.2-5 provides more detail on the report process (4.0). This figure shows that OPES can produce reports for submittal to the MMS, "change" reports which summarize any changes made to the central database since it was last modified, and summary and detail reports on the contents of the central database.

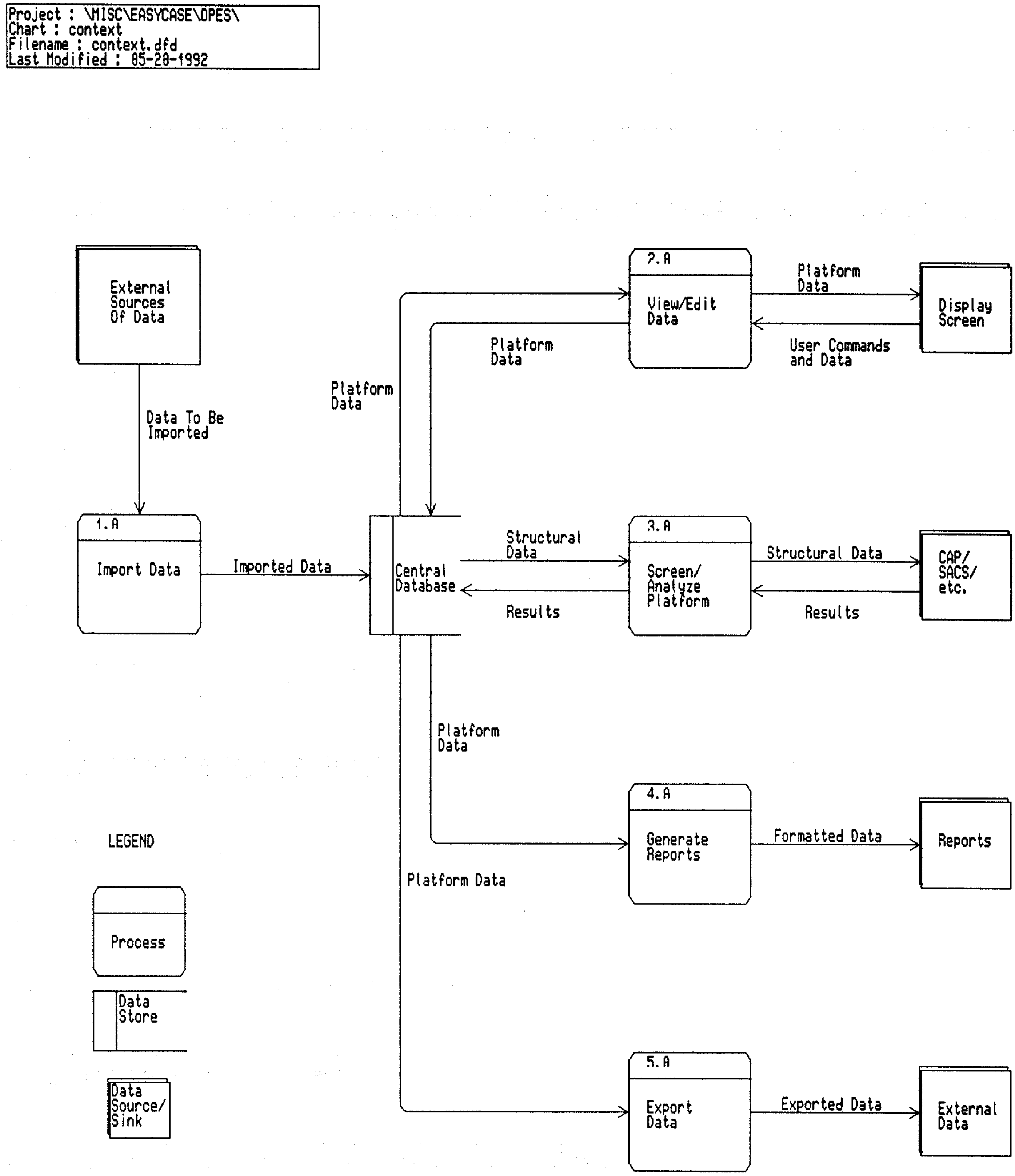


Figure 3.2-1: Context Diagram

Project : \MISC\EASYCASE\OPES\
Chart : import
Filename : import.dfd
Last Modified : 05-20-1992

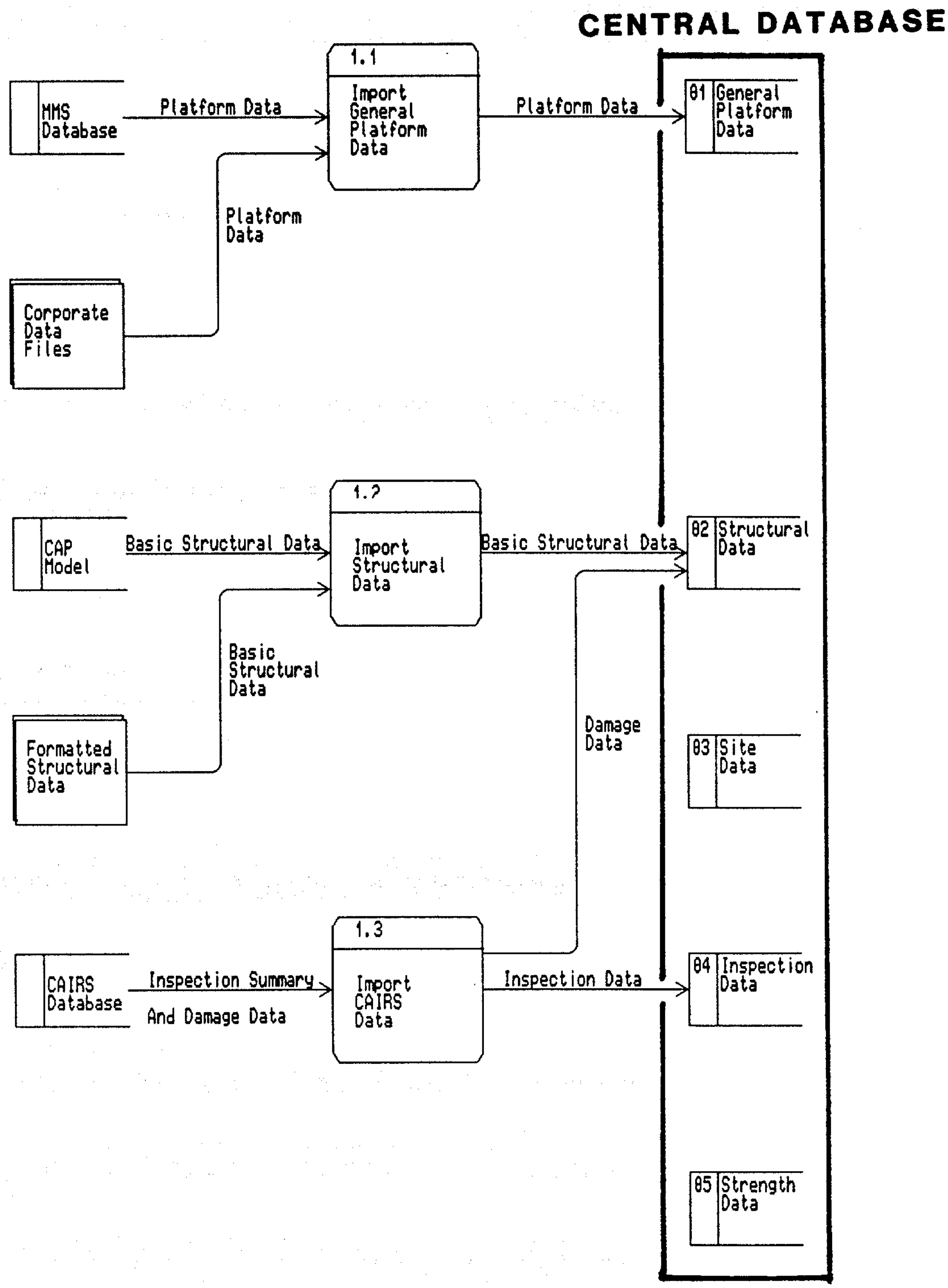


Figure 3.2-2: Import Data Flow Diagram

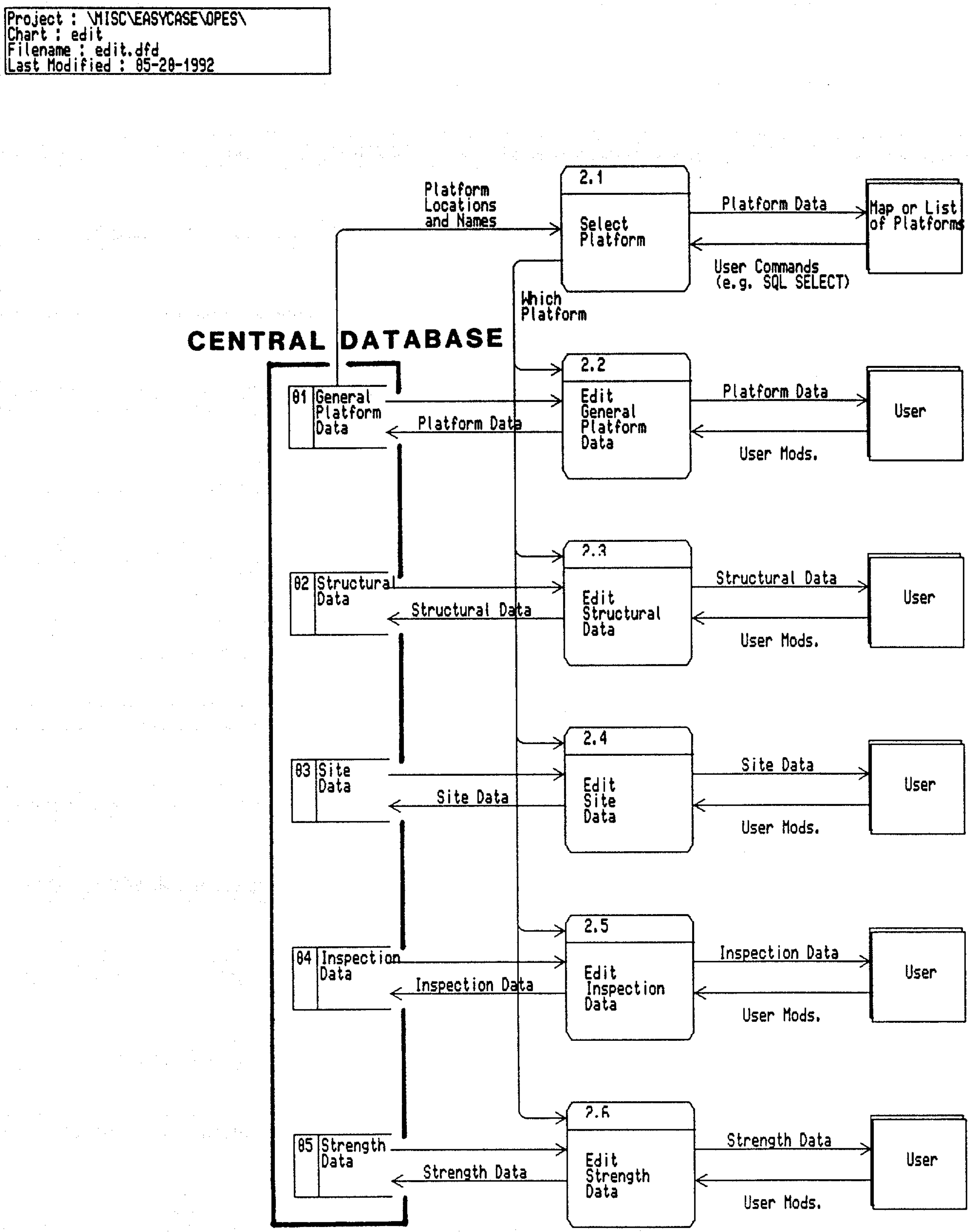


Figure 3.2-3: Editing Data Flow Diagram

Project : \MISC\EASYCASE\OPES\
Chart : analyze
Filename : analyze.dfd
Last Modified : 05-20-1992

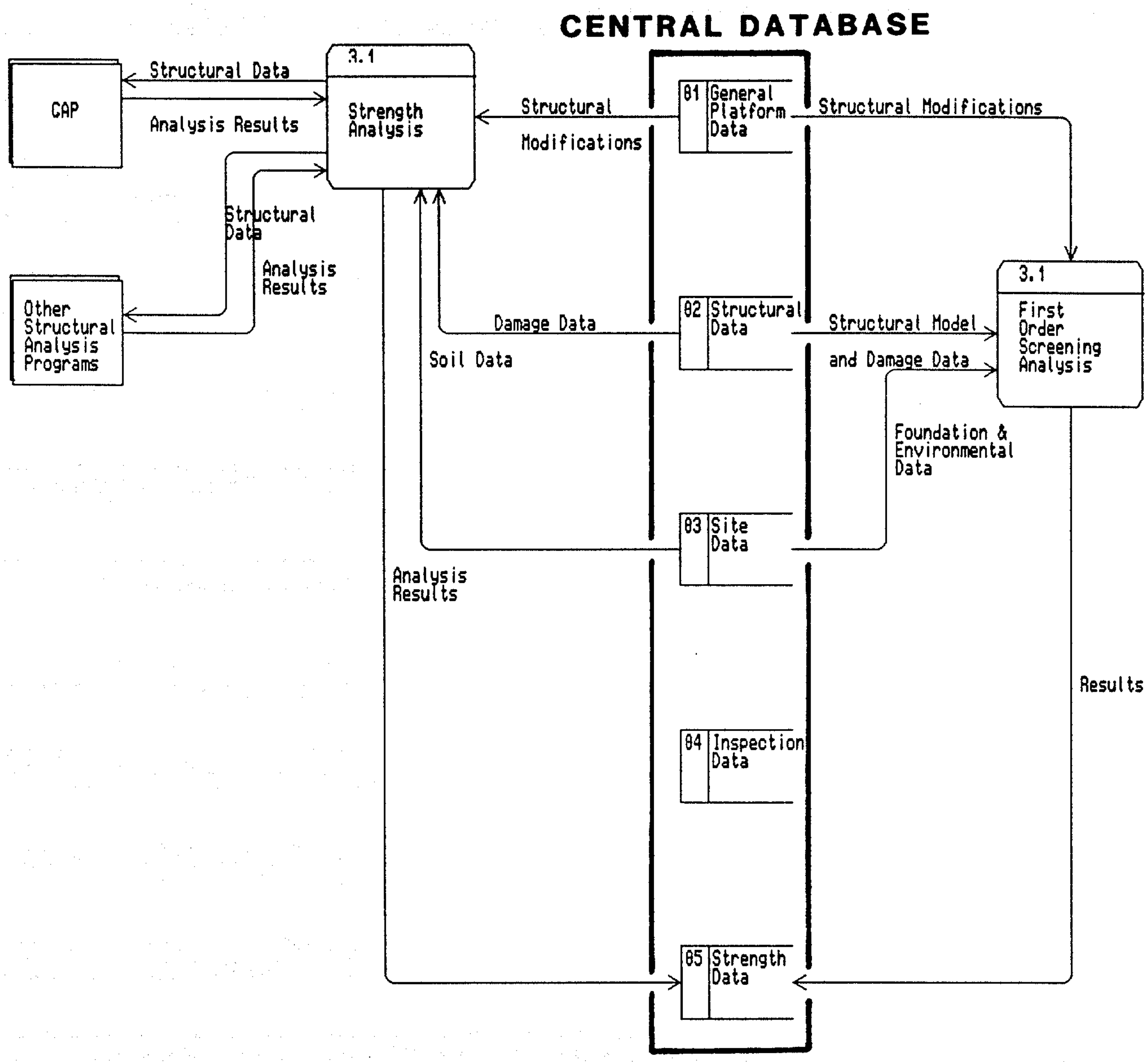


Figure 3.2-4: Analysis Data Flow Diagram

Project : \MISC\EASYCASE\OPES\
Chart : report
Filename : report.dfd
Last Modified : 05-20-1992

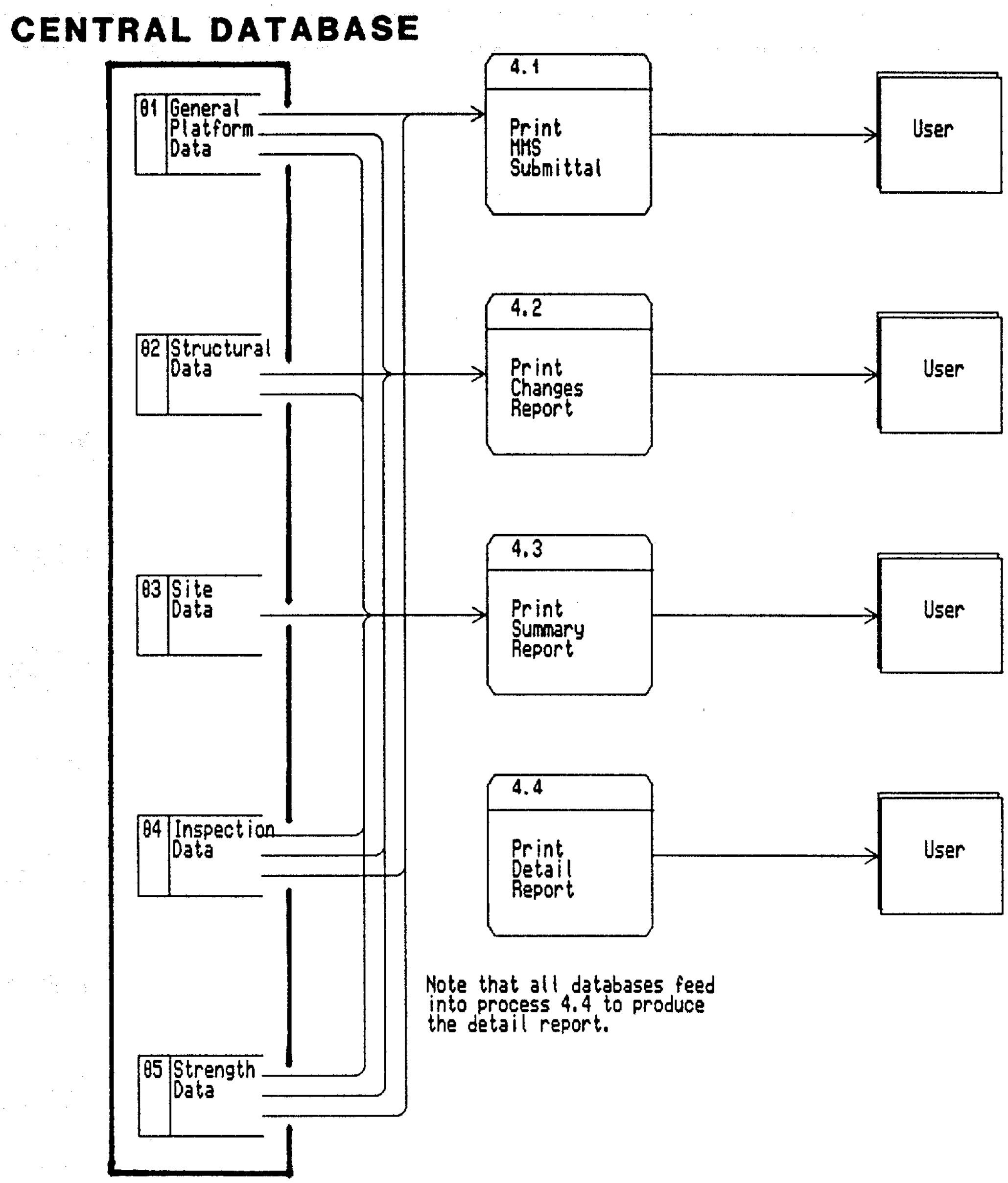


Figure 3.2-5: Report Data Flow Diagram

3.3 Information Content

This section documents the contents of each of the databases described in the previous sections. Note that while some specific information is provided for each database, it is very preliminary in nature and subject to further review and analysis.

DB-01: General Platform Data

This database contains general information about each platform, including its MMS ID, name, owner, age, location, and water depth. Specific contents include:

- Platform Description
  - Platform ID, per some type of MMS classification (e.g. Ship Shoal 199-A)
  - Owner
  - Block or Area
  - Original Designer
  - CVA
  - Platform Type (Production, Drilling and Production, Quarters, Transfer Station, Storage, Other)
  - Structure Type (Conventional Fixed Base, Caisson, Tripod, Cook Inlet, TLP, FPS, other)
  - Manned/Unmanned (identify number of personnel)
  - Number of Wells
  - Evacuation Methods (boat, helicopter)
  - Helideck Size (or none)
  - Type of Production - oil/gas
  - Production Rate - bbl/day
- Age Information
  - Date Installed
  - Original design life
  - Current estimate of remaining field life
  - Number of wells
  - Original Design Basis (RP2A Edition, Lloyds, other certification basis)

DB-02: Structural Data

This database contains information about the jacket and deck structure, including locations of all nodes, member connectivity, properties, and sizes, piles, conductors, appurtenances, and other pertinent information.

There are two reasons for storing this information in OPES:

1) To provide a means of communicating with an external structural analysis program so that the analysis process can be automated, in particular, the ability to update an existing model to account for changes to the platform and damage discovered during inspections.

2) To provide the capability to display a graphical representation of the structure within OPES.

The intent is not to be able to generate a complete structural model from the data stored in OPES. It is assumed that a detailed structural model will be built outside of OPES for whatever program is used to perform the strength evaluation.

Specific contents of this database include:

- Jacket Structure
  - 3-Dimensional coordinates of all nodes
  - Tubular member sizes (20" dia 5/8" wall thick, etc.)
  - Unusual jacket members, if any (AISC W or T Shapes, etc.)
  - Joint cans - length and wall thickness
  - Material type - A36, A537, etc. Mill certification data if available.
  - Intentionally flooded members
  - Weld details (i.e. profiled, ground)

- Jacket Foundation System (Piles assumed)
  - General Type - leg, skirt
  - Number of piles
  - Location of each pile - Leg A1, Leg B1, etc
  - Diameter, wall thickness and schedule - by pile
  - Material type - A36, A537, etc. Mill certifications?
  - Original pile design penetration
  - Actual penetration depths - by pile, per driving records or estimated
  - Pile connection - welded/grouted

- Jacket Conductors

    - Number
    - Sizes (26" dia, 3/4" wall thick, etc.)
    - Material type - A36, A537, etc. Mill certification data, if available.

- Jacket Appurtenances (item, location and size)

    - Walkways, barge bumpers, boat landings, stairways, etc
    - J-tubes and risers

- Jacket Corrosion Protection

    - Type - anode/impressed current
    - Number and location of anodes
    - Coatings or sheathing (monel)

- Jacket Damage

    - Dents
        - location - distance from leg, circular location (degrees or time coordinate)
        - size - diameter, length, depth
    - Cracks
        - type - partial or thru crack
        - location
        - size - length
    - Holes
        - location
        - size - diameter and length
    - Flooded Members
        - Members Checked
        - Members Flooded
    - Corrosion - material loss on members
    - Other?

- Deck Structure

    - 3-dimensional coordinates of all nodes
    - Tubular member sizes (20" dia 5/8" wall thick, etc.)
    - Other Deck Members (AISC, W, or T Shapes, channels, etc.)
    - Joint cans - length and wall thickness
    - Material type - A36, A537, etc. Mill certification data if available.

- Deck Equipment Information

  - Dead and live loads
  - Special concerns such as hook loads and localized loads from cranes, flarebooms, bridge to adjacent structure, etc.

- Deck Structural Appurtenances (item, location and size)

  - Drill rigs
  - Flare Booms
  - Bridges
  - Other

- Deck Structural Damage

  - Dents
    - location - distance from leg, circular location (degrees or time coordinate)
    - size - diameter, length, depth
  - Cracks
    - type - partial or thru crack
    - location
    - size - length
  - Holes
    - location
    - size - diameter and length
  - Corrosion - material loss on members
  - Other?

DB-03: Site Data

This database contains information about site where the platform is located, including its meteorological, oceanographic, geotechnical, and seismic properties. Specific contents include:

- Location Data
    - General Region - Gulf of Mexico, California, Alaska, etc, based upon some type of MMS classification. Signifies the general type of concern for platform (e.g. GOM means hurricanes).
    - Lease/Tract number - Ship Shoal 199
    - Coordinates
    - Orientation
    - Miles from shore

- Meteorologic - Oceanographic Data
    - Water Depth for design - MLW plus tide plus surge
    - Design wave height and period
    - Design current
    - Random seas, etc. that may be needed for compliant-type structures
    - Primary hydrodynamic loading directions
    - Marine growth (as function of depth)
    - General wave environment (e.g. Wave height/current versus return period for the site)
    - Other criteria that may need to be addressed:
        - Operating environment (etc)
        - Fatigue environment (etc)
    - Design Wind Speeds
    - Air Temperature Extremes (for Arctic applications)

- Geotechnical Data
    - General type (soft clays, stiff clays, silts, sands, etc.)
    - Soil profile - soil layers and engineering properties
    - Strength profile (strength versus depth, if available)
    - Pile-soil strength curves (p-y and t-z, if available)
    - Other special soil issues (e.g. - mudslide zone)

- Seismic Data

    - Strength level data - strength level spectra
    - Ductility level data:
        - ductility level spectra
        - ductility level time history (e.g. scaled Loma Prieta)
    - General seismic environment (e.g. peak ground acceleration versus return period)
    - Deck spectra

- Other Data

    - Ice conditions

- Original Criteria

    - Original environmental design criteria, if available (e.g. wave heights, Cd, Cm, soils, etc.)

DB-04: Inspection Data

This database contains information summarizing any inspections that have been performed on the platform. Specific contents include:

- Inspection Chronology
    - Date
    - Descriptive Short Name (e.g. yearly inspection, inspection following large hurricane, etc.)
    - Performed By (Oceaneering, etc.)
    - Further Written Detail (memo)

- Summary Results
    - Jacket Damage
        - Dents
            - location - distance from leg, circular location (degrees or time coordinate)
            - size - diameter, length, depth
        - Cracks
            - type - partial or thru crack
            - location
            - size - length
        - Holes
            - location
            - size - diameter and length
        - Flooded Members
            - Members Checked
            - Members Flooded
        - Corrosion - material loss on members
        - Other?
    - Deck Damage
        - Dents
            - location - distance from leg, circular location (degrees or time coordinate)
            - size - diameter, length, depth
        - Cracks
            - type - partial or thru crack
            - location
            - size - length

- Holes
  - location
  - size - diameter and length
- Corrosion - material loss on members
- Other?

- Detailed Results
  - Link with CAIRS

- Inspection Plans
  - Next Scheduled Inspection
  - Descriptive Short Name
  - Further Written Detail

DB-05: Strength Data

This database contains information summarizing any screening or strength analyses that have been performed on the platform. Specific contents include:

- Assessment Chronology
  - Date
  - Descriptive Short Name (e.g. Static pushover, Dynamic pushover, quick check following boat impact damage, etc.)
  - Performed By (Operator, PMB, etc.)
  - Further Written Detail (memo)

- Summary Results
  - Type of evaluation - unity check, capacity check, both.
  - Unity check
    - Number of members overstressed per design criteria
    - detail of overstressed members plus their unity check
  - Capacity check
    - Platform capacity (kips, etc.)
    - Load-deformation curve (global shear vs deck deflection)
    - Return period of wave causing platform failure
    - Distance wave is above or below deck at failure
    - Reserve Strength Ratio

- Detailed Results
  - Link with CAP

4. FUNCTIONAL MODEL

This section describes the functional model for OPES. It begins by listing the major functional requirements of the system. It goes on to illustrate the partitioning of the functions into modules, in the form of structure charts. Finally, it provides details on how some of the functions will be performed.

4.1 Functional Requirements

Note that due to the preliminary nature of this specification, the following functional requirements are general, not specific, in nature. A final software specification suitable for design and coding of a program should have a detailed list of specific requirements, each of which could be independently verified as having been met in the final product. Such detail is not appropriate for OPES at this time.

A review of the OPES project report [1] reveals the following main requirements for OPES:

1) <u>Provide a database for storing general information on a fleet of platforms, and provide a means to maintain this database.</u>

   In order to be valuable to the MMS and to operators that have more that one platform, OPES must be able to store information on many platforms and allow the user to view and manipulate this data. The user may want to see where the platforms are located via a map shown on screen, and may want to view subsets of the data (i.e. by using database query commands). Examples of subsets are: all the platforms installed before a certain date, all the platforms owned by certain operators, platforms that are manned, installed in deep water, and haven't been inspected for the last "n" years.

   Note that it is not important that this database provide access to all the details on each platform. Rather, the intent is to allow the user to select a platform for further processing.

2) <u>Provide a means to query the database containing information on a fleet of platforms for the purpose of selecting subsets of the platforms that have certain characteristics.</u>

   A number of operators in the Gulf of Mexico have several hundred platforms. For this reason OPES must assist the user in identifying a subset of platforms for further processing. For example, the user may want to review all platforms that were designed before API RP 2A was in place, or that were installed before 1969, are currently manned, and are producing oil. In the event of an approaching hurricane, the user may want to know what platforms are in the path of the hurricane and which of those is most at risk (e.g. old platforms with RSRs less than 1.5).

To meet this requirement, OPES must provide a means to perform SQL-like queries on the database. It must present the user with a list of fields in the database, allow the user to select a field for the query and specify the criteria for the field, and then indicate in some way the results of the query. In addition, the user must be able to string multiple queries together with basic boolean logic (AND, OR, NOT, etc) so that a highly-specific subset of the database can be identified.

For example, the user may select "INSTALL DATE" as a field for a query, and specify "< 1970" as the criteria. OPES should then either mark graphically all platforms which meet this criteria on screen, or display a list of the platforms. The user may then select "BLOCK" as a field and "Eugene Island OR Ship Shoal" as the criteria, and how this new query is related to the previous one (i.e. AND, OR etc). OPES should then indicate the results of the combination of these queries, and allow the user to continue or to start a new query.

3) <u>Provide a database for storing detailed evaluation information related to a specific platform, and provide a means to maintain this database.</u>

OPES must be able to store a variety of detailed information about a specific platform, as described in Section 3. In addition, the user must be able to view and update this data. As much as possible, OPES should present the information in forms which are easily understood by the user. In some cases this may be in the form of a list, in others in the form of text, and in others in the form of an on-screen graphic view of the platform.

For example, the results of an inspection may be best summarized via text (i.e. in the form of a memo). However, if the user wants to know what a platform looks like and where any damage is, this is best shown in the form of a 3D graphic view.

4) Provide a means to import inspection data from other programs into the detailed platform database.

Some of the data which OPES must store may be available in electronic form, and OPES should allow the user to import this data as easily as possible, rather that having to re-type it. Inspection data may be stored in an existing CAIRS database and OPES should be able to import this directly. Other inspection data may be stored in third-party or operator-developed databases (or perhaps in word processor files), and OPES should have a means to import this data as well (perhaps through a pre-defined fixed format ASCII data transfer).

5) Provide a means to import structural configuration and strength data from other programs into the detailed platform database.

As stated above, some of the data which OPES must store may be available in electronic form, and OPES should allow the user to import this data as easily as possible, rather that having to re-type it. Structural data may be stored in an existing CAP database and OPES should be able to import this directly. Other structural data may be stored in third-party or operator-developed programs (e.g. SACS), and OPES should have a means to import this data as well (perhaps through a pre-defined fixed format ASCII data transfer).

6) Provide a means for structural analysis programs to obtain strength-related information from the detailed platform database.

OPES should make the process of re-evaluating a platform as easy and error-free as possible, using up-to-date information. For example, a recent inspection may have found a dent in a member. OPES should allow the user to electronically send information like this to an outside structural analysis program so that that program can read it and perform a new analysis, and send the results back to OPES.

7) Provide a means to perform first-order strength estimates on platforms and to put the results in the detailed platform database.

In addition to providing access to a rigorous structural analysis program to perform strength evaluations, OPES should include the ability to perform first-order strength estimates (see [1] for more discussion on this). This means that OPES must store all the required structural data, and include its own analysis module.

8) <u>Provide a means to perform detailed ultimate strength analyses of platforms, via a link to other programs, and to put the results in the detailed platform database.</u>

It is not feasible (nor necessarily desirable) to include within OPES the ability to perform rigorous strength analyses. However, these results are important for the evaluation of platforms and OPES stores these results in its databases. OPES should therefore provide a link to other programs to perform these analyses and retrieve the results. This means that OPES must store and send to another program (see item 5 above) as much information as possible, and must be able to import the results of the analysis.

9) <u>Generate reports suitable for submittal to the MMS for platform re-qualification.</u>

In some cases, the results of platform assessments are submitted to the MMS for review. OPES should make this process as painless as possible for its users by automatically generating the appropriate reports from the information stored in its databases.

10) <u>Provide access to as much information as possible from outside of OPES.</u>

The OPES databases should be designed to provide access to all information from outside of OPES. This may be accomplished by using a standard database format (e.g. dBase III) so that third-party software can be used to read and modify the databases, perform ad hoc queries, and generate reports. This will give the user the ability to do things that were not considered during development of OPES, and will make it easier for users to expand and adapt OPES to their specific requirements.

11) <u>Provide a modern user interface.</u>

OPES should include a modern user interface that is easy to learn, easy to use, and easy to pick up if someone has not used the program for some time. In addition, the user interface should present information in ways that are easy for a human to understand and assimilate (e.g. graphical views of platform locations and geometry, query-by-example for selecting subsets of data, etc). OPES should allow the user to view data in several unit systems, provide on-line context-sensitive help, notify the user of the status of its operation, and allow use of either a keyboard or a mouse for as many operations as possible.

12) <u>Run on commonly-available hardware and be portable to many different computer systems.</u>

OPES will be used by many companies, as well as the government. In order to be available to the widest possible audience, it should run on a commonly-available computer (the IBM PC is the most likely candidate), but should be written such that it can be moved easily to other computer systems. During implementation of OPES the following computer systems should be considered: IBM PC, Macintosh, Unix workstation (Sun, HP, and IBM).

13) <u>Provide both written and online documentation.</u>

In addition to providing the usual written documentation, OPES should make as much information available online as possible, in a context-sensitive manner. Documentation should include a user's manual describing how to use the program, an installation manual describing how to install the program, and a reference manual describing the menu systems and each user dialog in detail, as well as the structure of the databases and how to access them from outside OPES. Each data entry screen the user sees should have an index number leading to a description in the documentation.

14) <u>Allow use of other programs (e.g. SACS, company inspection DBs, etc).</u>

As much as possible, OPES should allows the user to incorporate information from other programs and databases (perhaps through a pre-defined "generic" fixed format ASCII data transfer).

4.2 Functional Partitioning

This section describes the overall architecture of OPES in the form of structure charts. Structure charts depict the hierarchy of the modules in a program, and illustrate the relationship of the modules and how they communicate with each other.

Note that due to the preliminary nature of this specification, this section does not go into much depth. A final specification will provide significantly more detail on this subject. Only one structure chart is provided here, as an example of the type of information that will be included in the final specification.

The chart in Figure 4.2-1 presents a simple overview of the architecture of OPES, and illustrates the first level of detail for the functions associated with importing data. Note that the numbers in the module blocks refer to the process numbers shown on the data flow diagrams in the previous chapter.

Figure 4.2-1 indicates that each major process in OPES has its own place in the module hierarchy, and that the process are controlled at a high level by the user. To import data, OPES calls the import/export module, telling it what to import. This module in turn determines the name of the file containing the data and calls another module to do the actual work (e.g. module 1.1 to import MMS data). Note that modules 1.1 - 1.5 are still fairly high-level modules that would probably call other modules to do pieces of what needs to be done, and that some of the modules they call may be utility modules used in several places. However, it is not appropriate at this time to carry the functional partitioning any further.

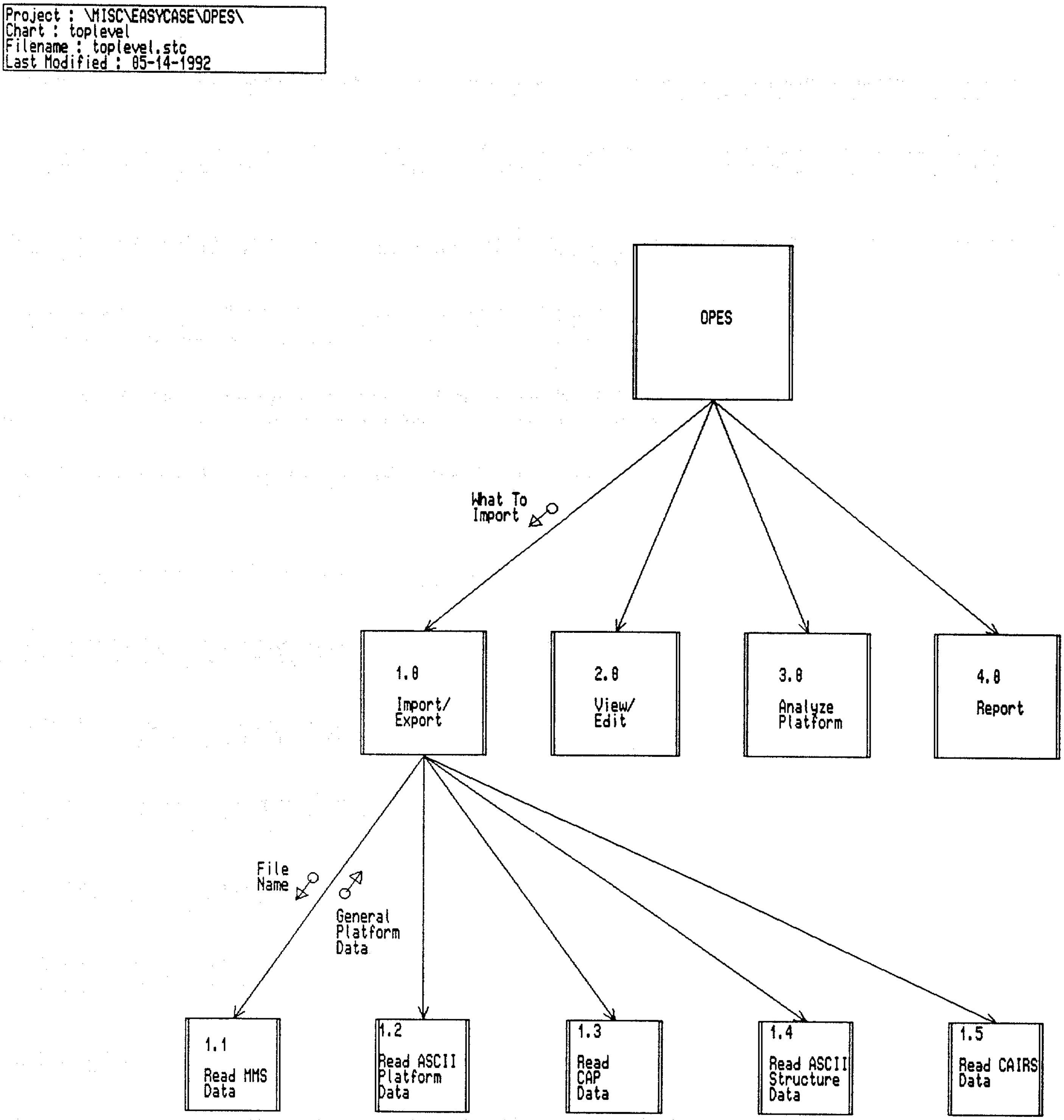


Figure 4.2-1: Top Level Functions

4.3 Functional Descriptions

This section describes in structured English how each of the functions within the modules performs its work. The purpose is to describe what each module does and to illustrate roughly how it does it, but the implementation details are left to the final designer and programmer. A programmer will use this information to implement OPES.

Again, due to the preliminary nature of this specification, this section does not go into much depth, and a final specification will provide significantly more detail on this subject. Only one function description is provided here, as an example of the type of information that will be included in the final specification.

Function 1.1 : Import MMS Data

Summary : This function imports data from the MMS database into the appropriate OPES databases.

Input : Name of file containing MMS data.

Output : Flag indicating success or failure.
Number indicating how many platforms were read from the file.

Calls : Database utility functions.

Description : Clear error flag.
Initialize record counter to zero.
Open MMS data file.
If file cannot be opened:
    Set error flag.
    Return error flag and number of records read.
Read a record from the data file.
While there is no error or end of file:
    Parse record.
    Store data in databases (using DBMS utility functions).
    Increment count of records read.
    Read next record.
If there was an error, set error flag.
Close data file.
Return error flag and number of records read.

5. USER INTERFACE MODEL

This section illustrates the preliminary design of the user interface for OPES. A prototype of the user interface has been developed in the form of a ToolBook application which can run under Microsoft Windows. Refer to the "READ.ME" file on the diskette which contains the prototype for details on how to run it.

5.1 Anticipated Users

A variety of people with different needs and abilities may user OPES, and the user interface should account for this. The following types of users should be considered:

- A clerk in an oil company responsible for entering and maintaining basic platform data.
- An engineer responsible for coordinating and evaluating inspections.
- An engineer responsible for determining the strength of the platform.
- An engineer responsible for determining if the platform is suitable for further use, and/or for submitting reports to various government agencies.

5.2 Description of Prototype

Based on the requirements stated in this document, the description of OPES contained in the final report [1], and discussions with potential users, a prototype of the user interface for OPES has been developed.

Figure 5.2-1 illustrates what the user first sees when OPES is started. In this case we see a graphical view of the Gulf of Mexico showing the coastline, lease areas and blocks, and a dot representing the location of any platforms in the central database. At this point the user can pan the view across the Gulf, and zoom in on a particular area. A selection on the "Options" menu allows the user to toggle various attributes of the display (e.g. coastline, lease areas, blocks, etc) on and off.

Note that while this prototype is geared towards the Gulf of Mexico, the "File" menu can be used to open other OPES databases which may contain platforms in other areas of the world.

At this point the user is likely to want to choose a subset of the platforms in the database on which to perform other operations. Selecting "Find Platforms..." from the "Edit" menu leads to the screen shown in Figure 5.2-2. Here the user specifies what criteria are to be applied to select the subset, and how this selection is to be combined with other selections. In this case the figure illustrate how the user might select all platforms owned by the National Oil Company which are more than 10 years old.

When the user has completed the "Find Platforms..." operation OPES shows a subset of the platforms in its database as illustrated in Figure 5.2-3. In addition to presenting a graphical view of the platforms, OPES can also display a list, as shown in Figure 5.2-4.

At this point the user may want to review the information stored for one particular platform. This may be done by clicking on the dot representing the platform on the map, or on the line naming the platform in the list. As an alternative, the user may want to move in for a closer view of a particular area or block. Figures 5.2-5 and 5.2-6 show how the screen would look after zooming in to a particular lease area or block, respectively. At the block level shown in Figure 5.2-6 the platform names are displayed and the user can click on the square representing a platform to select it as the one to review.

When the user has selected one particular platform the screen appears as shown in Figure 5.2-7. Here we see the platform name and a graphical view of its framing. The user can pan, zoom, and rotate the graphical view, and toggle between 2D and 3D views. Selecting "Inspection Info..." from the "Analyze" menu causes different types of damage to be shown in different colors, as shown in Figure 5.2-8.

At this point the user can view any data stored for this particular platform, using the "Edit" menu and the buttons displayed at the bottom of the screen. The "Edit" menu lets the user select the basic categories of data, and the buttons correspond to sub-categories, as described in Appendix A of the main report [1]. Figures 5.2-9 and 5.2-10 illustrate what the user would see when viewing the platform description and oceanographic data, respectively.

If the user is interested in a particular damaged member, clicking on that member (see figure 5.2-8) magnifies that area of the platform and displays the damage data, as shown in Figure 5.2-11. Clicking on the damaged member again provides direct access to the inspection data stored in CAIRS (see Figure 5.2-12), at which point a picture of the damage may be viewed (see Figure 5.2-13).

Finally, the "Analyze" menu provides direct access to the screening modules of OPES, and to CAP and CAIRS (see Figure 5.2-14).

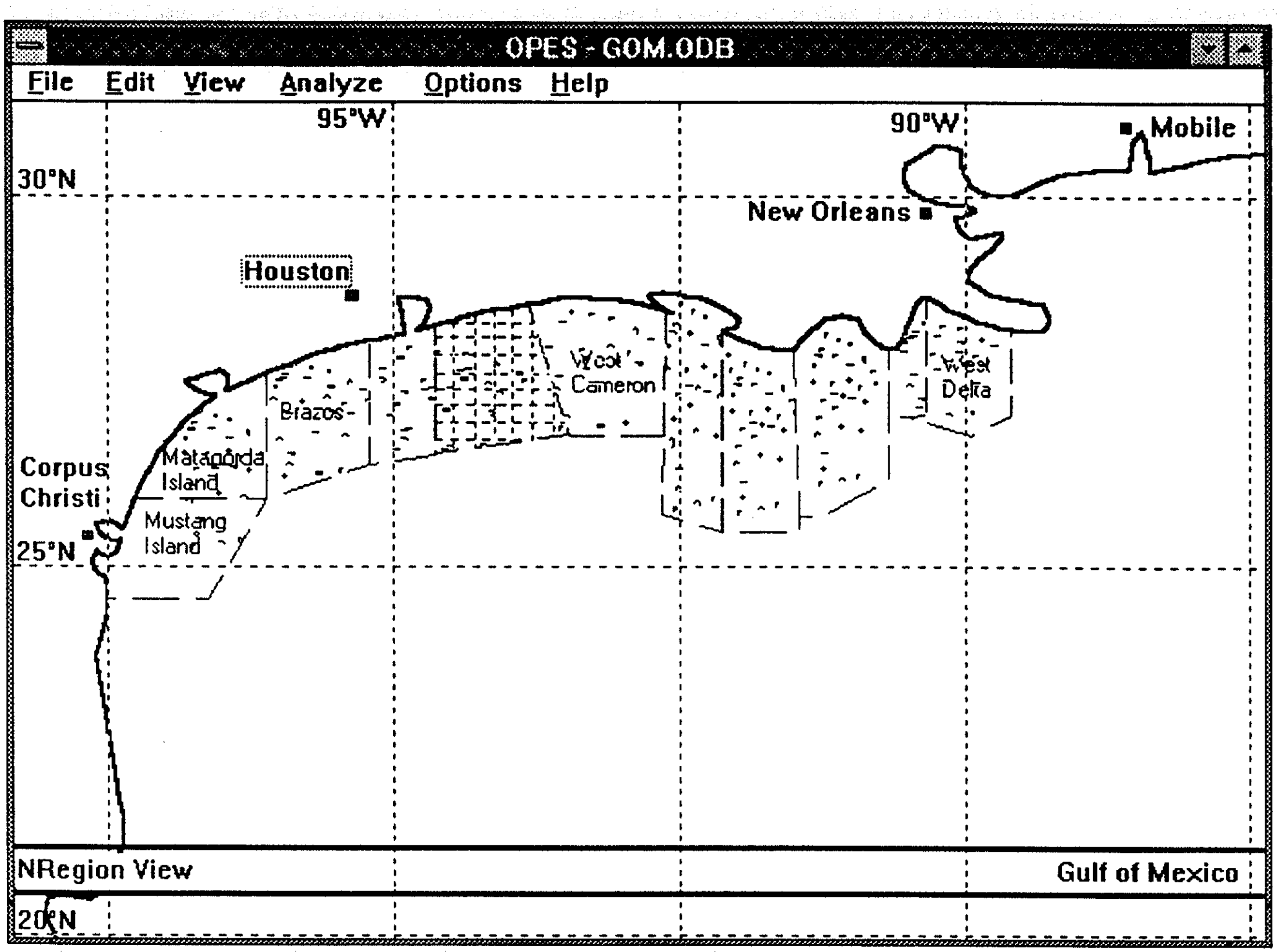


Figure 5.2-1: Main Screen

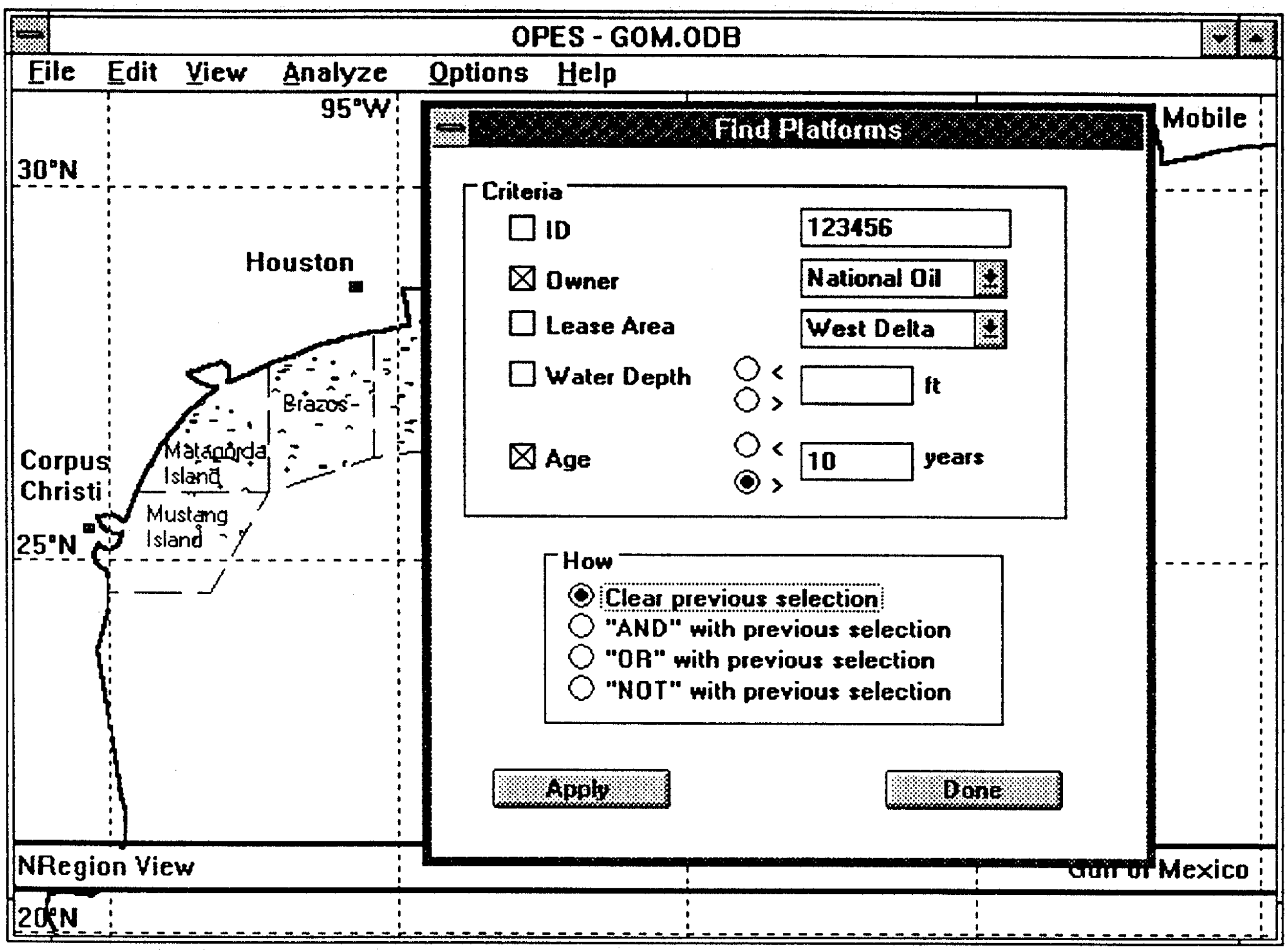


Figure 5.2-2: Selecting a Subset of Platforms

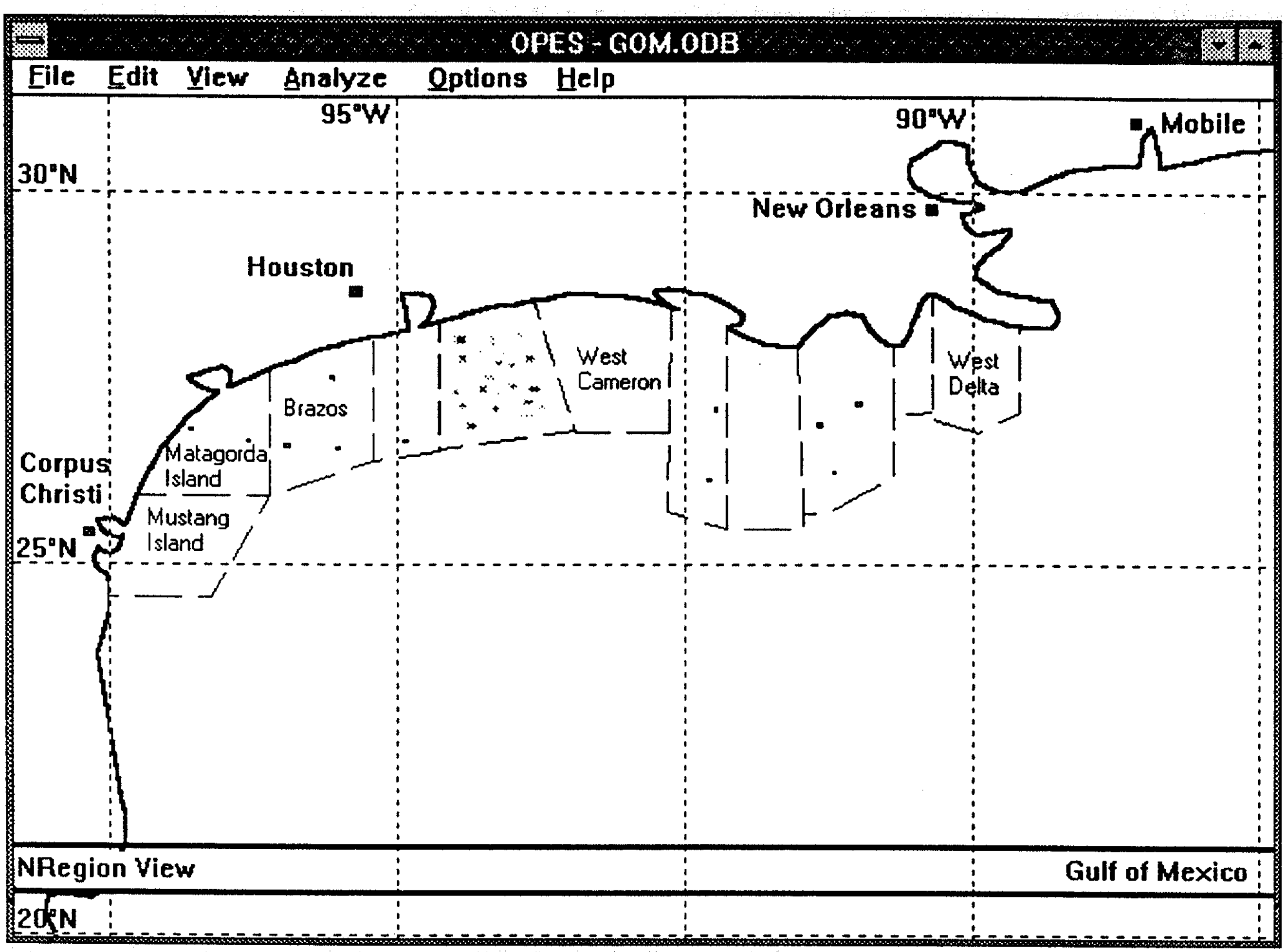


Figure 5.2-3: Main Screen with Subset Displayed

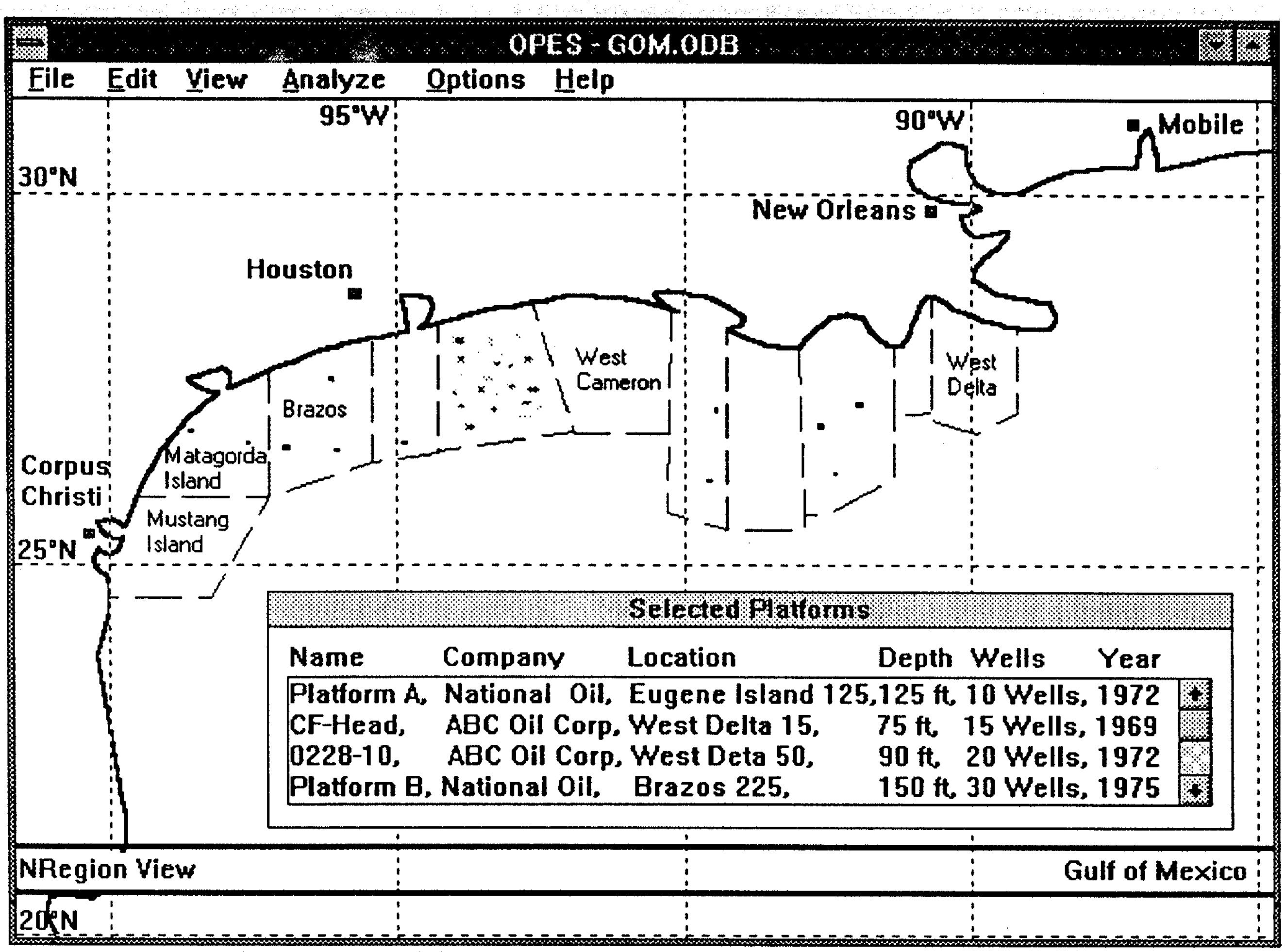


Figure 5.2-4: Main Screen with List Displayed

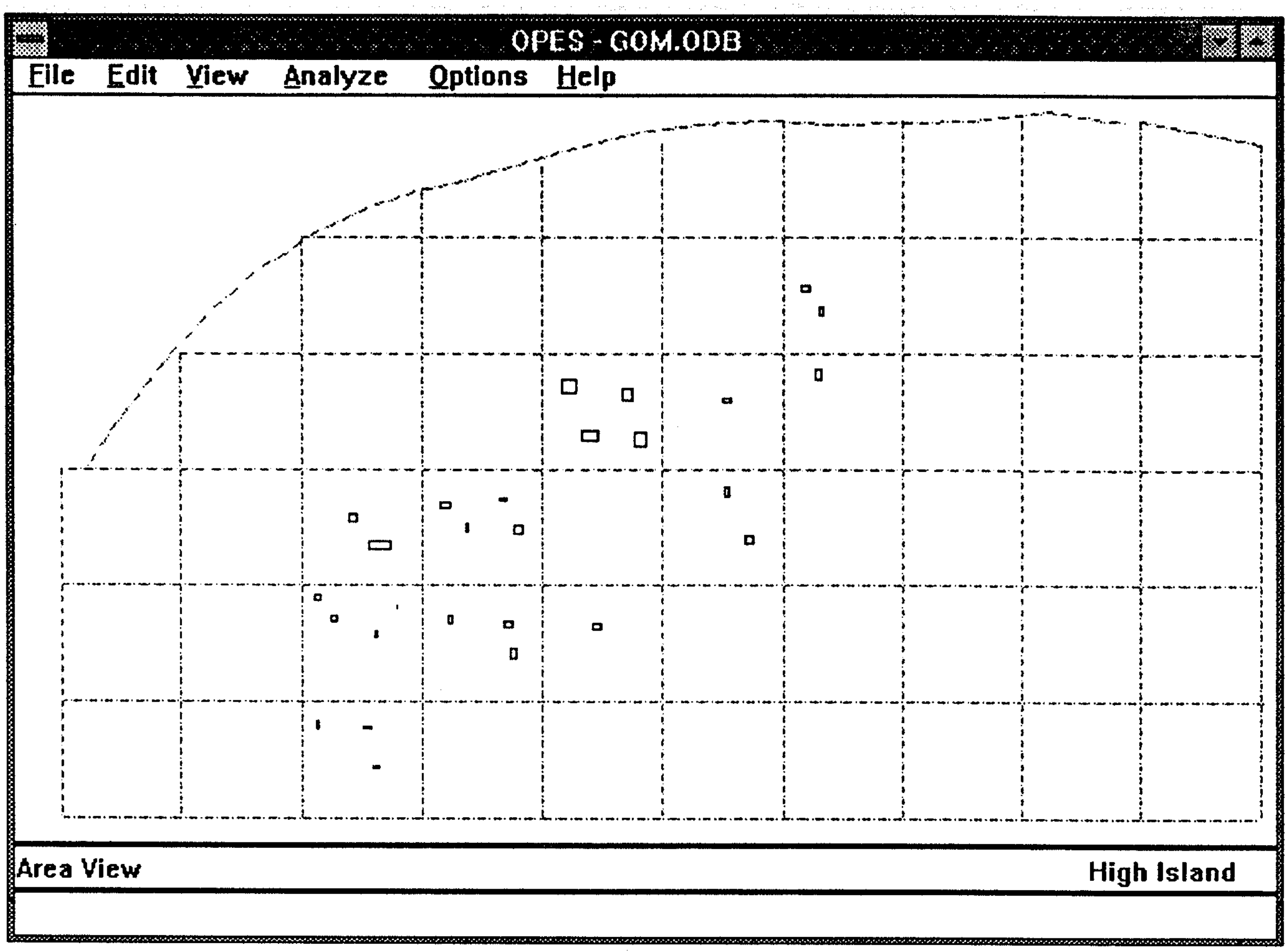


Figure 5.2-5: Zoomed View of Lease Area

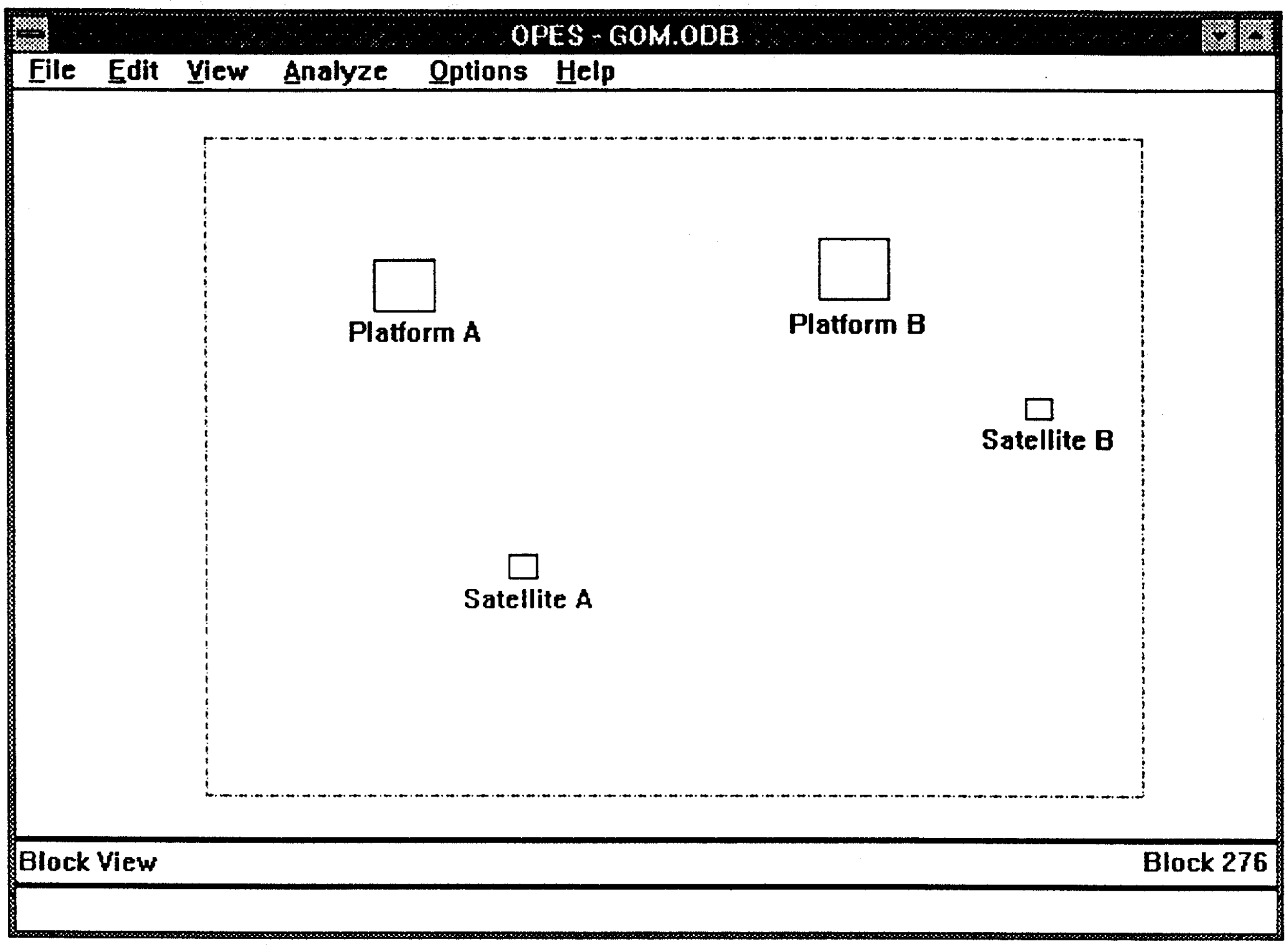


Figure 5.2-6: Zoomed View of Block

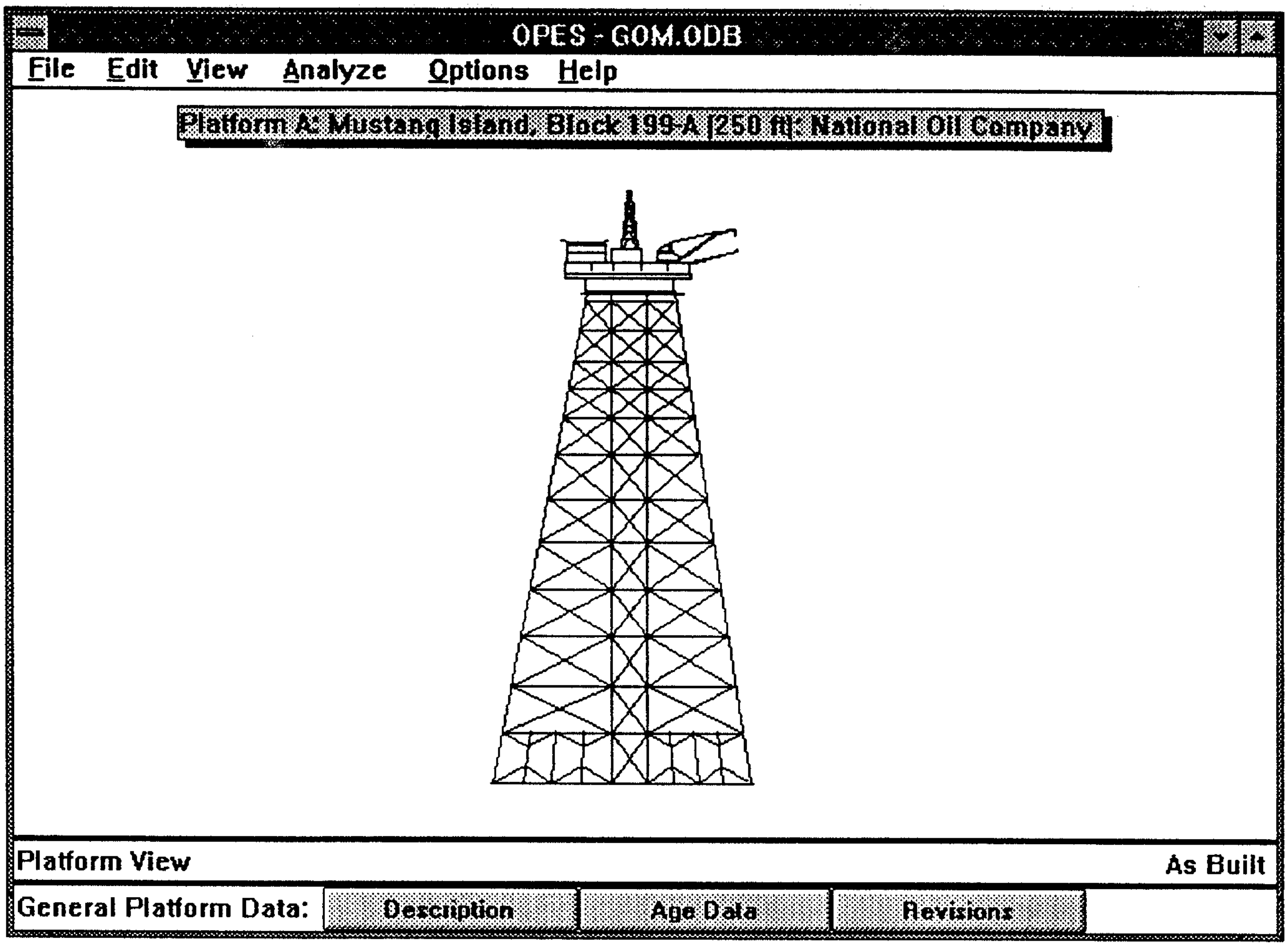


Figure 5.2-7: View of One Specific Platform

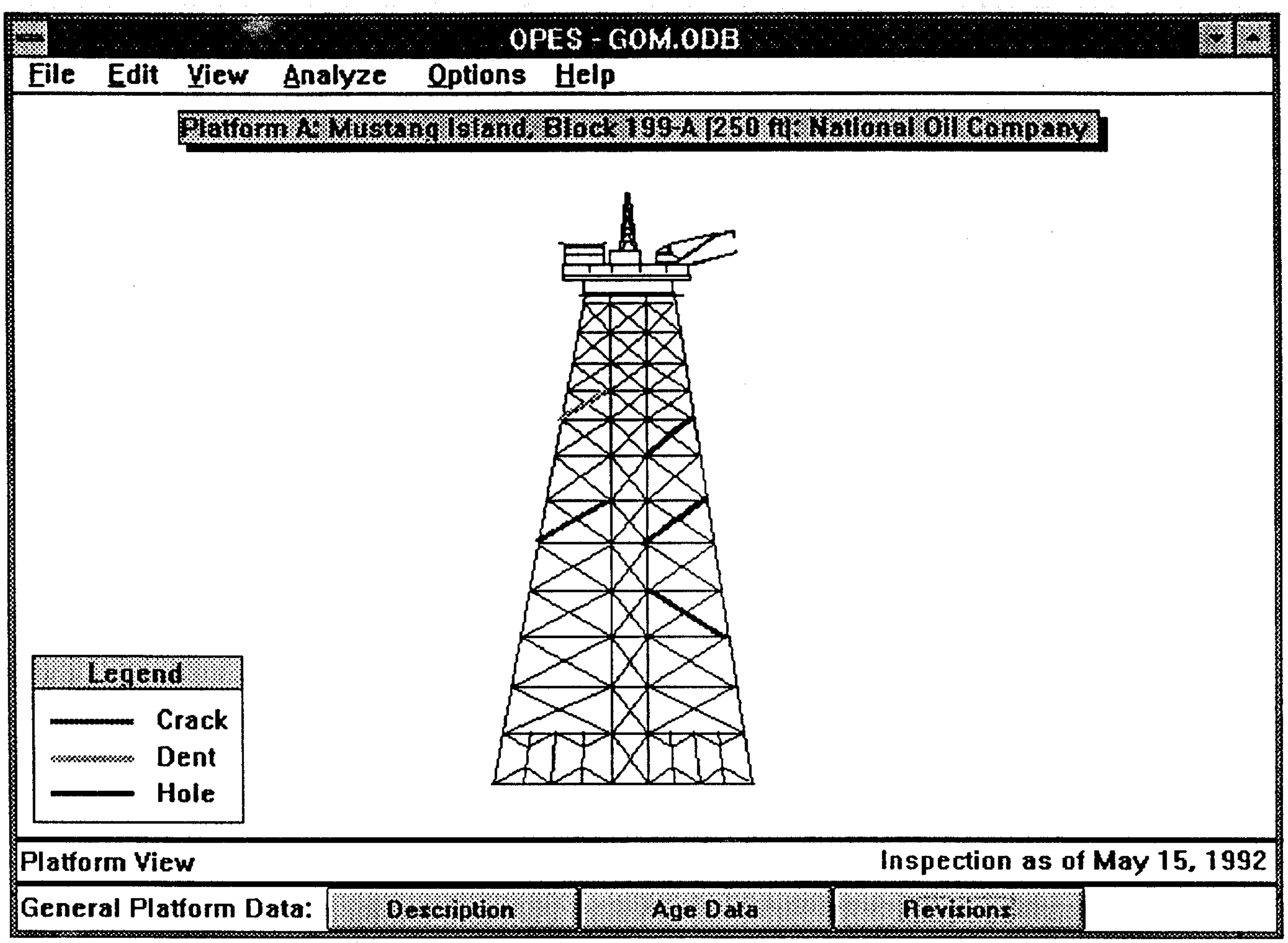


Figure 5.2-8: Platform View with Inspection Information

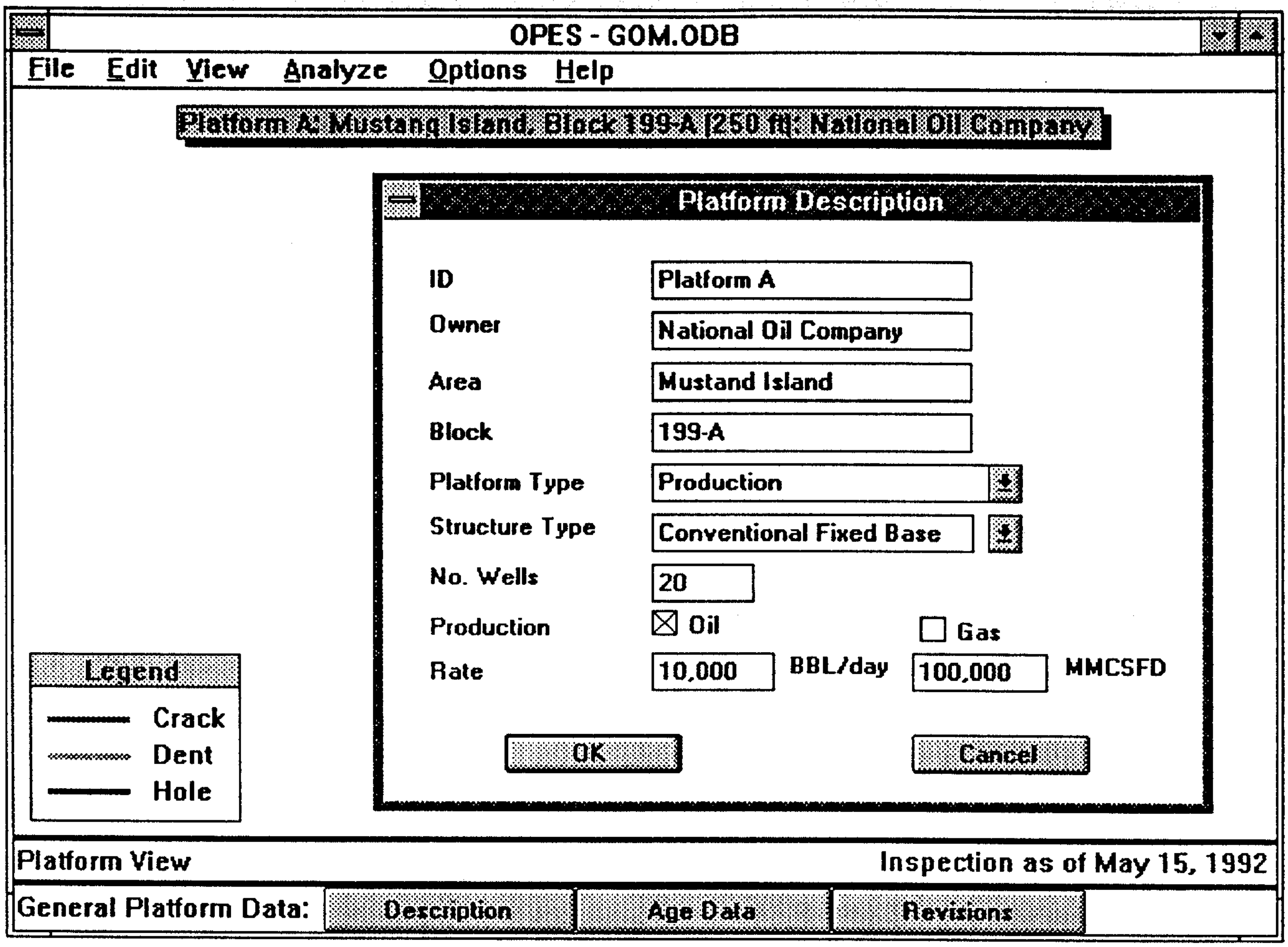


Figure 5.2-9: Platform Description

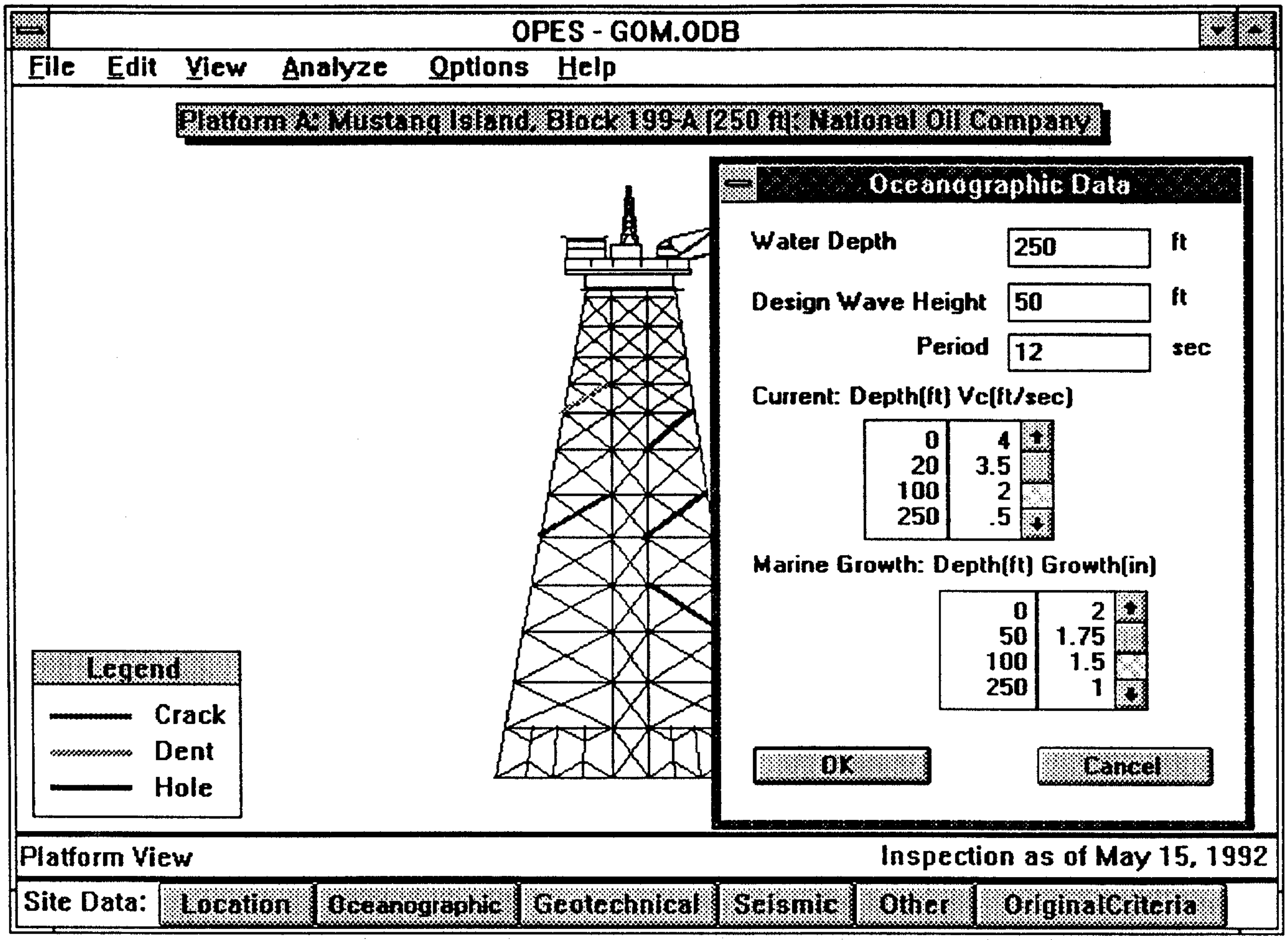


Figure 5.2-10: Oceanographic Data

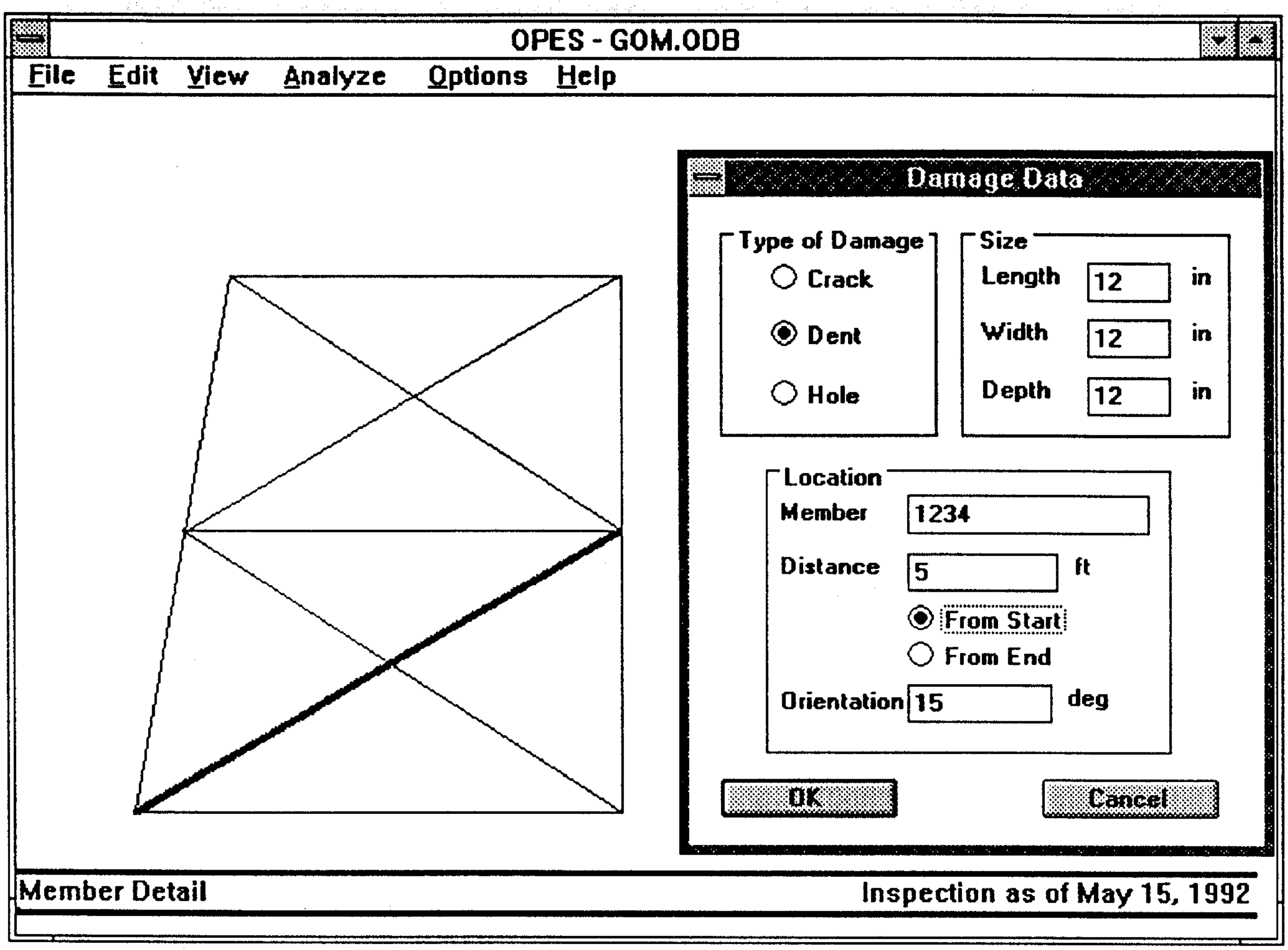


Figure 5.2-11: Damage Details

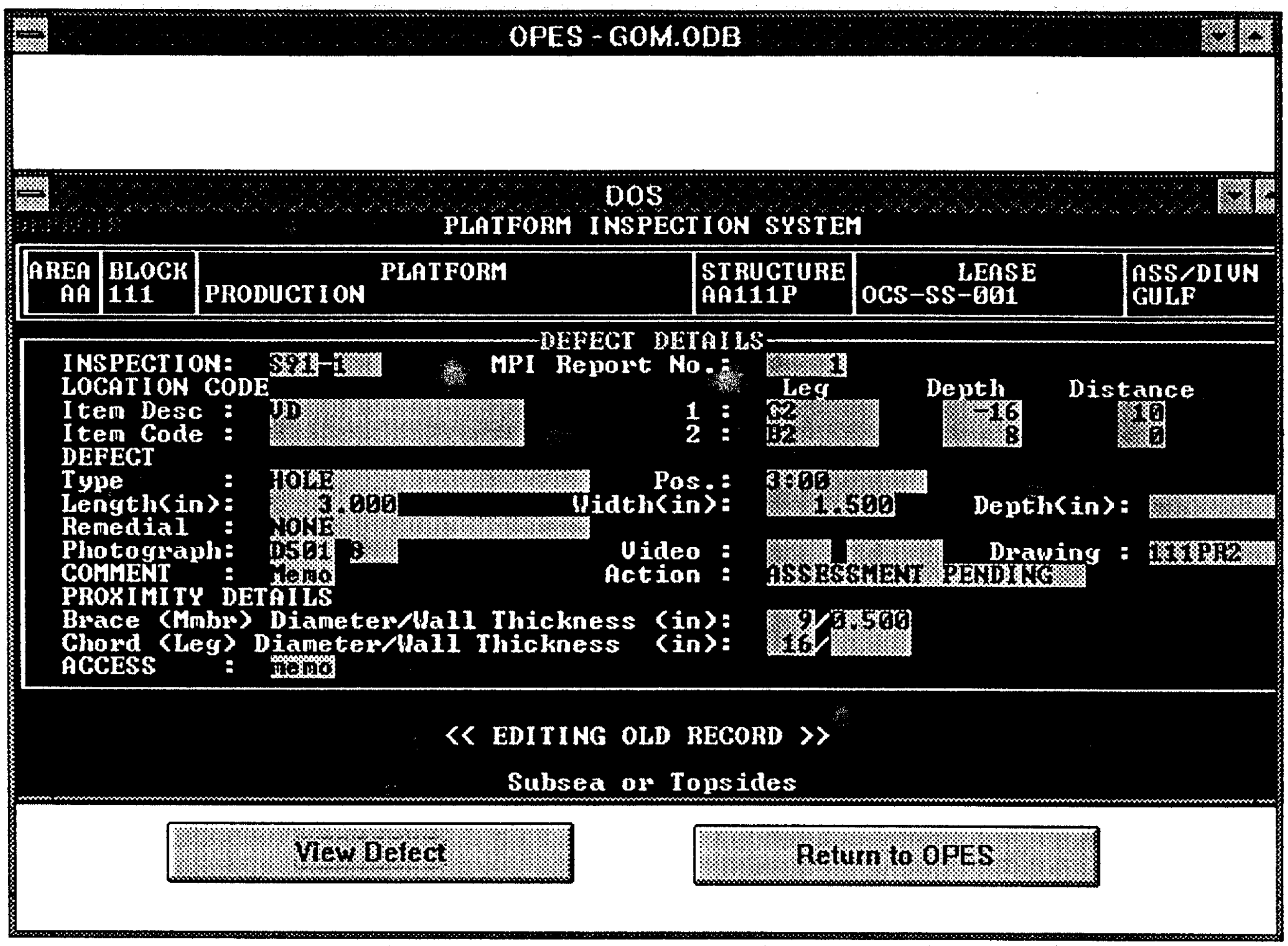


Figure 5.2-12: CAIRS - Damage Details

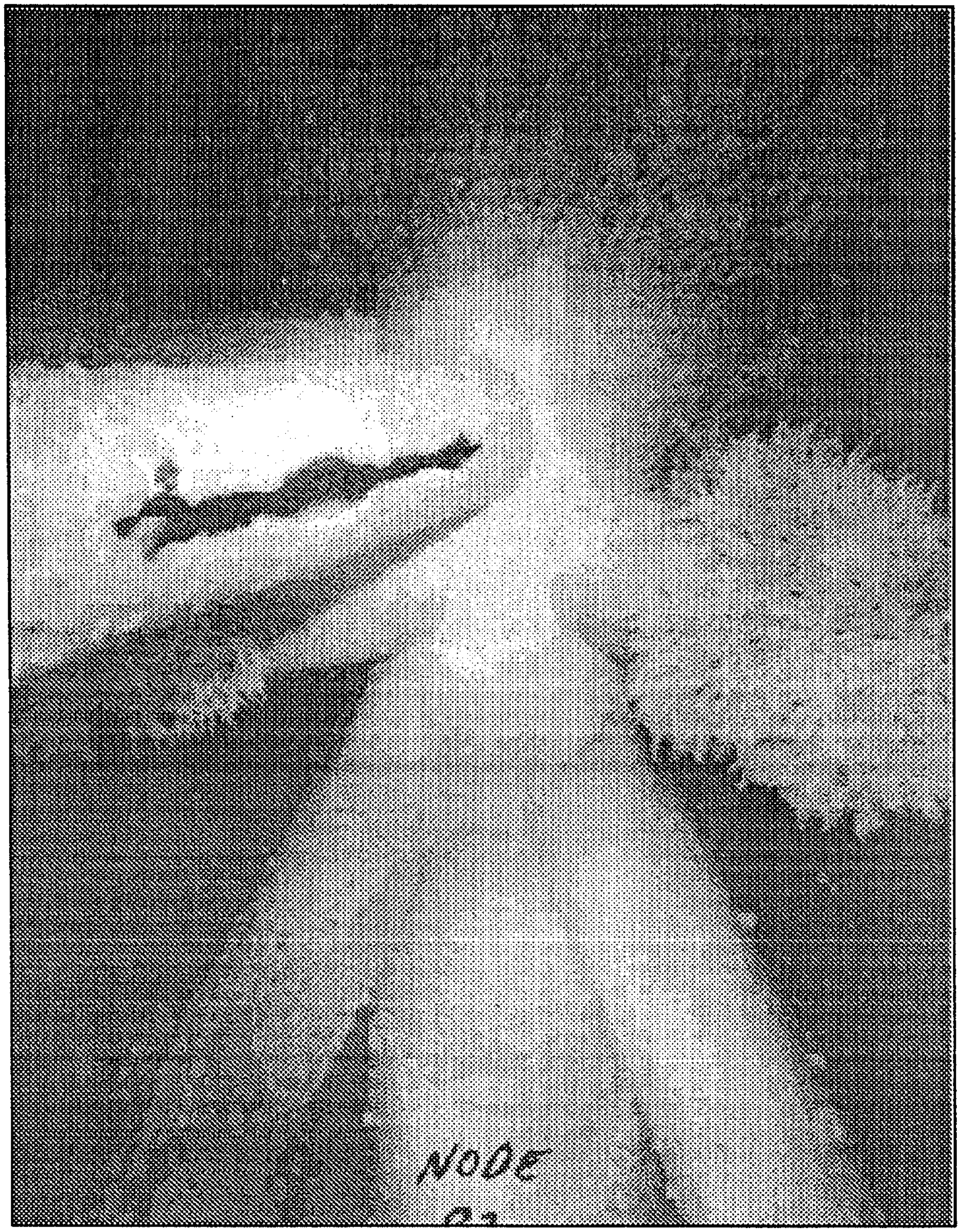


Figure 5.2-13: Photo of Damage

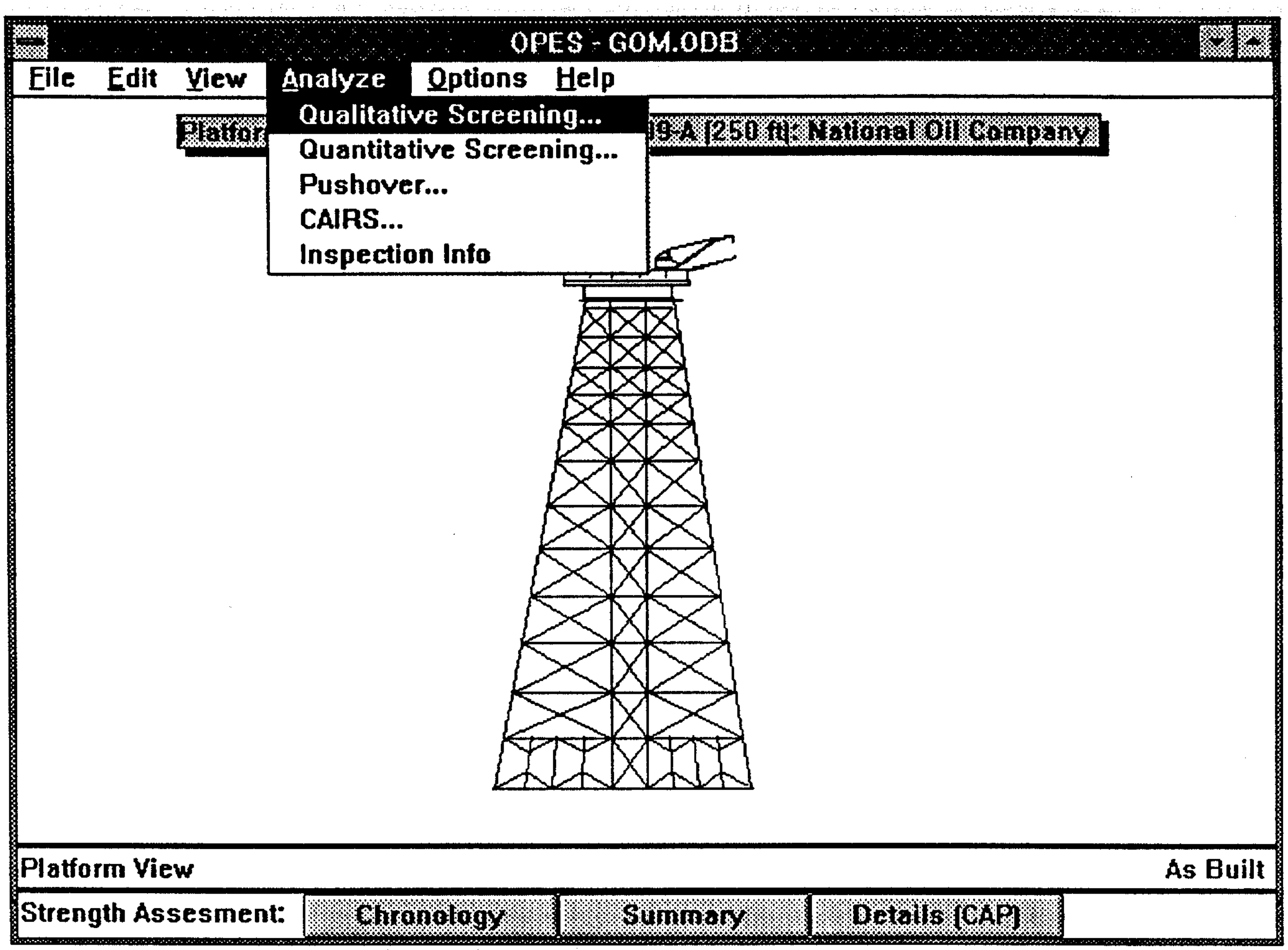


Figure 5.2-14: "Analyze" Menu

6. GENERAL REQUIREMENTS

6.1 Target Computer Environment

At this stage of the project it is not necessary nor desirable to specify the computer hardware required to run OPES. This should only be specified after the detailed requirements are finalized and the users have indicated their preferences. However, given the basic requirements described in this document and the general state of computer usage at various potential user's company, it is possible to state what the likely hardware will be.

It is apparent that OPES must store a lot of data, provide fast access to this data, include a modern user interface, and allow communication with other programs. In addition, it is generally more economical to use existing tools where possible to build the various pieces of a program like OPES.

These issues imply that the likely hardware will be an IBM-compatible 386- or 486-based computer with extra memory (probably 4 MB), a large hard disk (probably at least 130 MB), a high-resolution graphics display, keyboard, mouse, and network interface. The underlying operating system is likely to be DOS with Microsoft Windows providing the interface for the user. A commercially-available DBMS that can link to other databases on a network will provide the database functions. Likely candidates are Oracle, LAN Manager, Paradox, and others.

Other possibilities for the hardware system include Unix workstations running an X Windows-based interface such as Motif or Open Look, Macintosh computers, or a proprietary system. However, these systems are not nearly as widely available within a company as are IBM-compatible computers.

6.2 Documentation

The following documentation should be provided with OPES:

- A *User's Manual* which describes how to operate OPES, has examples of how to do various tasks, and which contains sample output available from the program.

- An *Installation Manual* which describes how to install OPES and get it to communicate with other software.

- A *Reference Manual* which describes the menu system and all user dialogs, and which specifies the structure of the databases.

6.3 Software Development Issues

This will be a brief section describing DBMS and user interface portability (XVT, Open Interface, etc) issues, coding standards, etc.